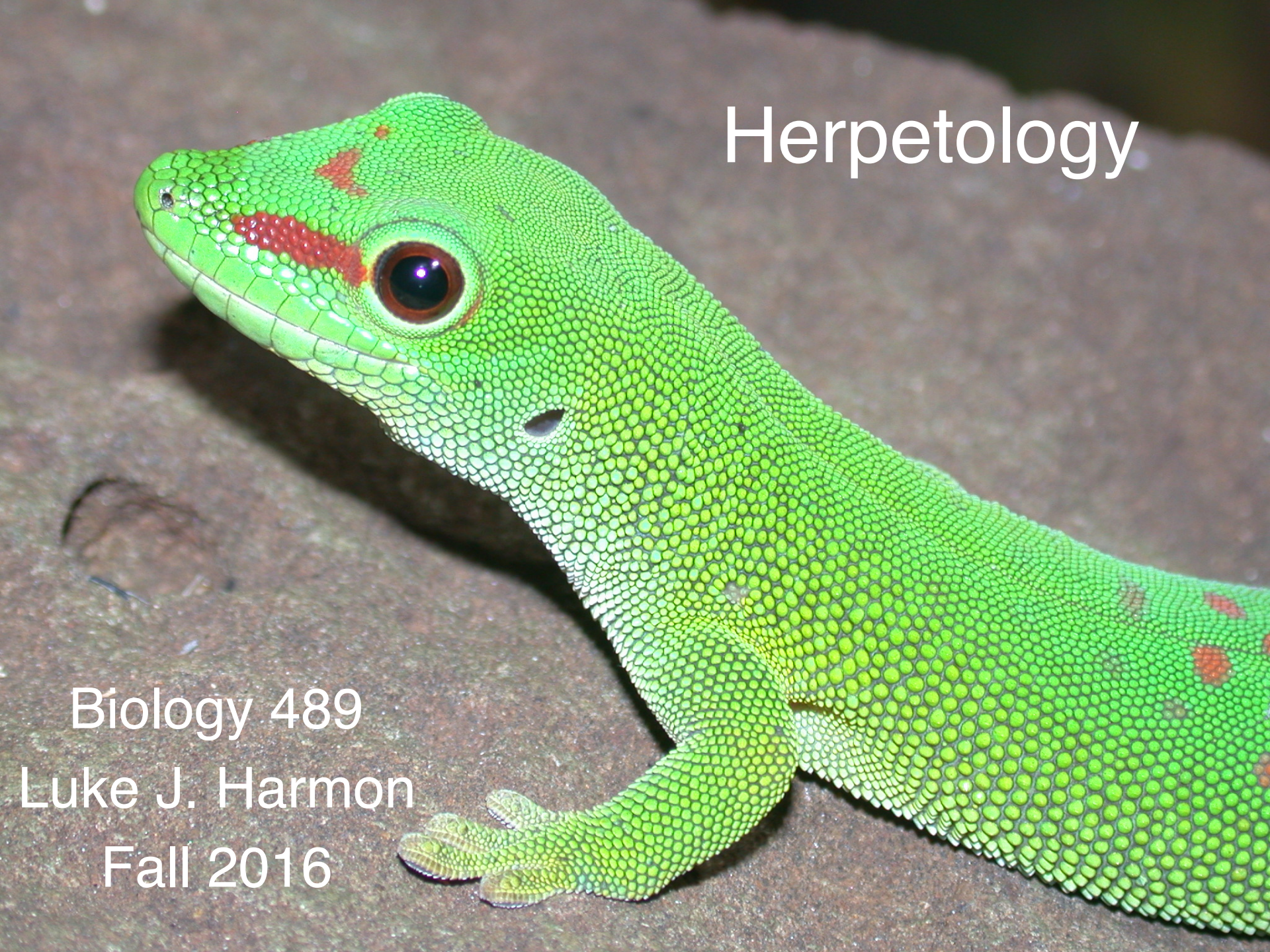
Herpetology
Biology 489
Luke J. Harmon
Fall 2016


Dr. Luke J. Harmon, LSS 347
Phone: 885-0346; Email: lukeh@uidaho.edu

Office hours: after class

– Life Sciences South (LSS) 347

– or by appointment (these are welcome!)

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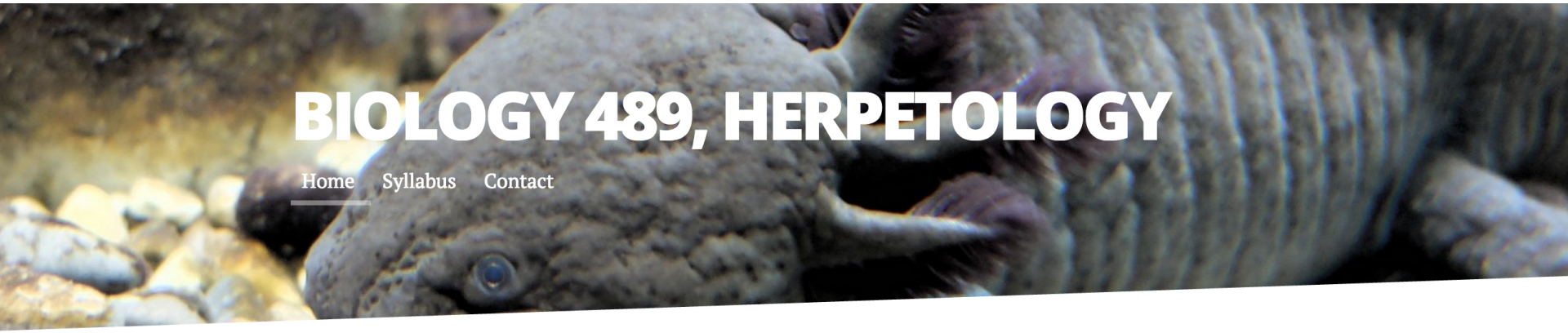


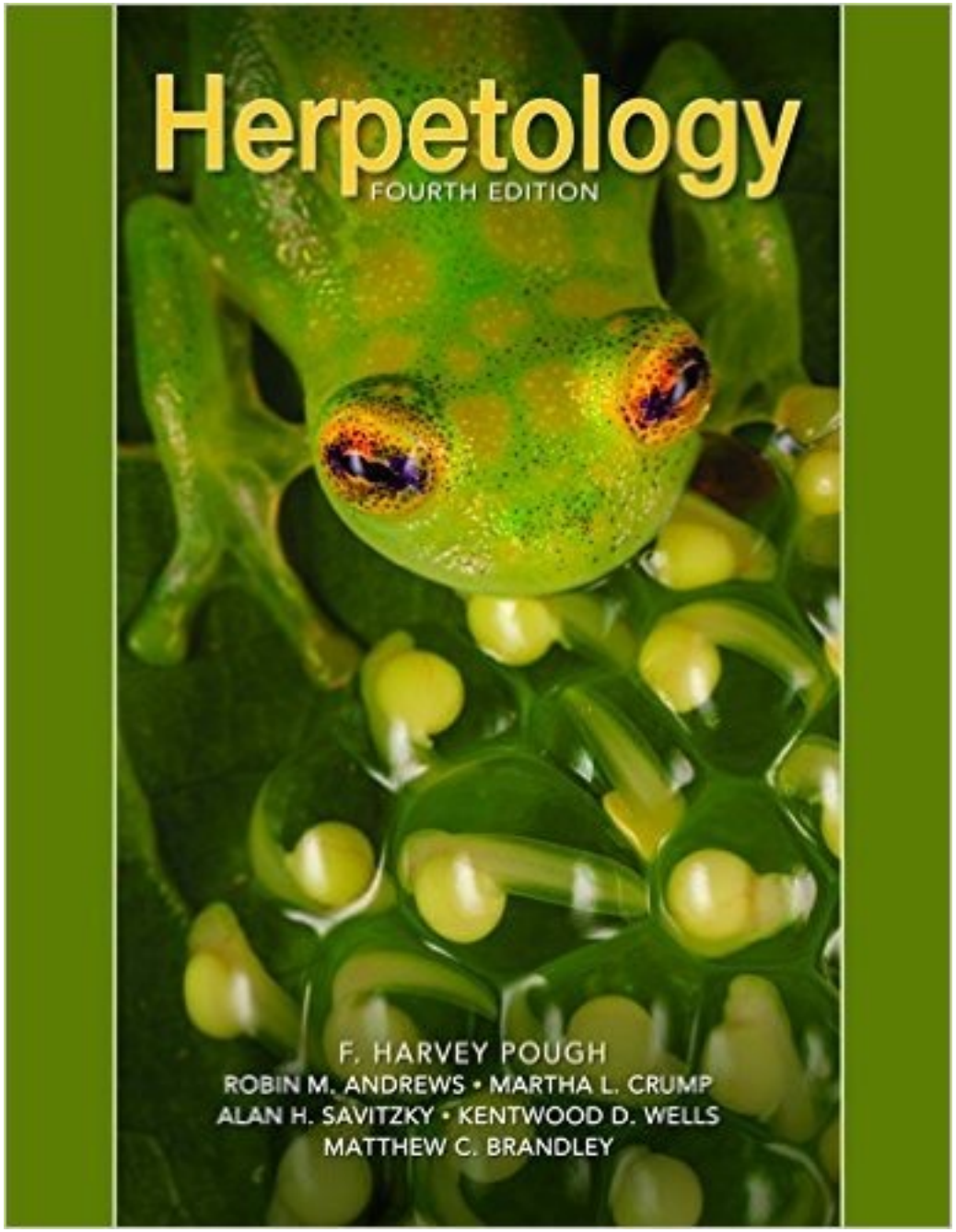
Recent Posts

August 20, 2015

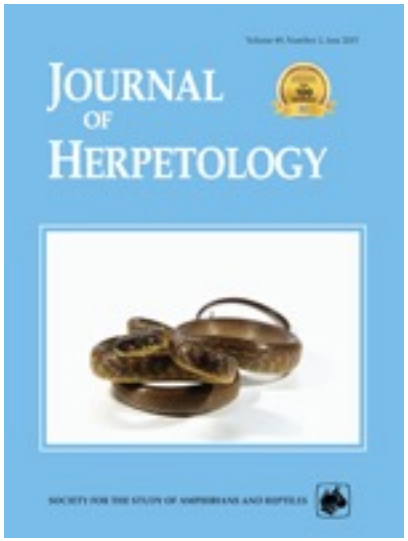
Macroevolution

Lecture 1 on Macroevolution is here

lukejharmon.github.io/herpclass

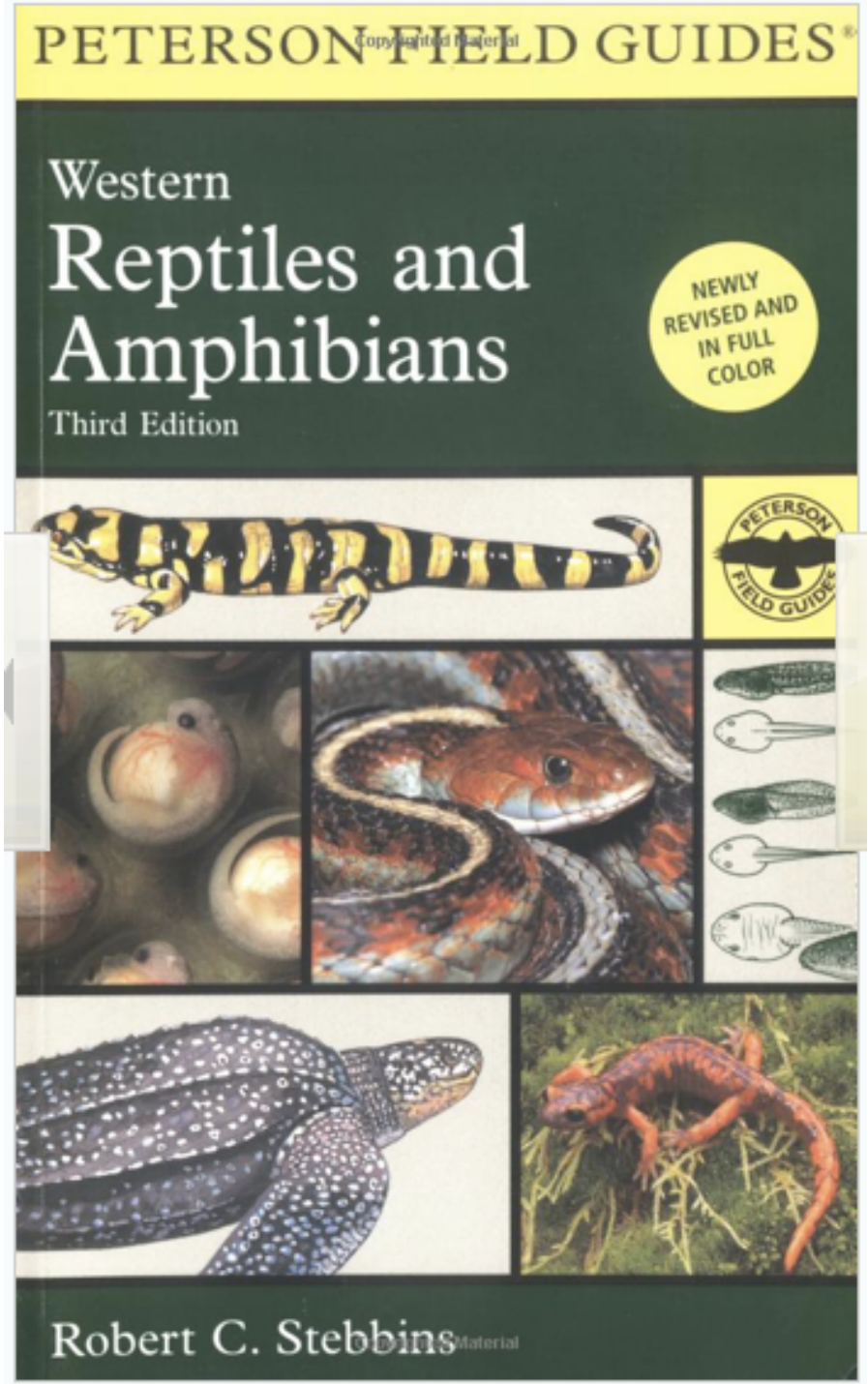

Herpetology
FOURTH EDITION
F. HARVEY POUGH
ROBIN M. ANDREWS • MARTHA L. CRUMP
ALAN H. SAVITZKY • KENTWOOD D. WELLS
MATTHEW C. BRANDLEY

(optional)


JOURNAL
OF
HERPETOLOGY


Copeia


nature
A SENSE OF FAIRNESS
Neural aversion to inequality
EXOPLANETS
The disappearing hot Jupiter
TOBACCO CONTROLS
WHO's treaty on trial
WINDS OF CLIMATE CHANGE
Tropical cyclones maintained permanent El Niño-like conditions in the early Pliocene



required and you need it by next week!

Course grading

Participation in Friday skypes	15%
Group Research Proposal	10%
Lab	25%
Exam I	15%
Exam II	15%
Final	20%
	100%

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Final	20%
	100%

Fridays = “meet the herpetologist”

R. Alexander Pyron, PhD
Robert F. Griggs Assistant Professor of Biology


Class
skype
Famous
Herpetologists

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Exam I	15%
Exam II	15%
Final	20%
	100%

Class Presentations

- Present a research proposal in lab on Nov. 17
- 15 minute class presentations
- Small groups (3 or 4 students)
- Key components:
  - What is known?
  - What is your question?
  - How can you answer that question?
- **Turn in a written summary and a budget**

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Final	20%
	100%

Course grading

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Group Research Proposal	10%
Lab	25%
Exam I	15%
Exam II	15%
Final	20%
	100%

Exams

- Exams are all short-answer questions
- The final will be **comprehensive**
- I will post examples of old exam questions on blackboard
- Note that the exams are 50% of your grade

Policies

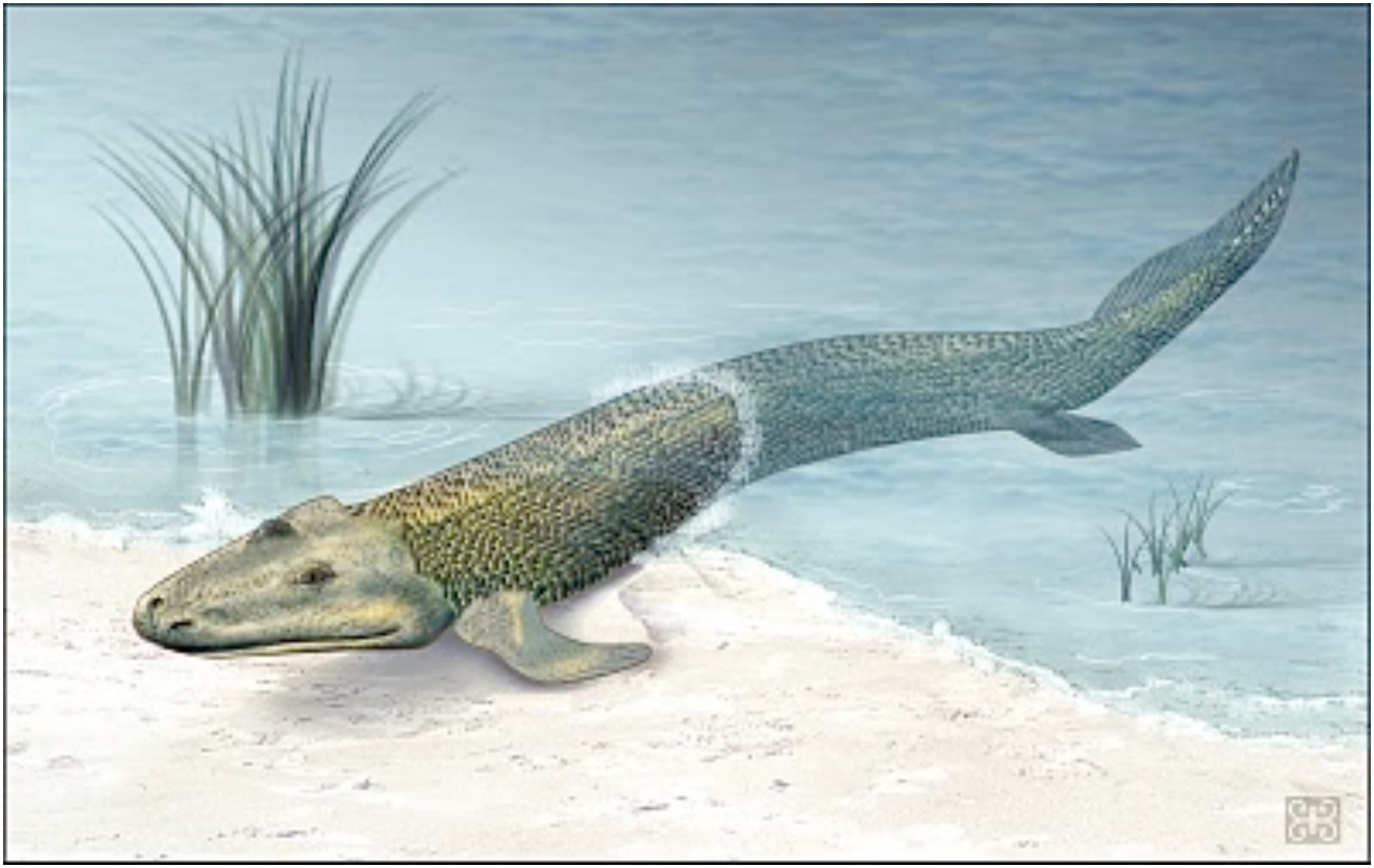
- Plagiarism and cheating: no thanks
- Make-up policy: let me know in advance; no make-ups for final
- Late assignments: 10% per day

why herpetology?

Integrative Biology

- Bringing together information from a wide variety of levels of organization
- Goal: to understand how organisms relate to, and interact with, their environment

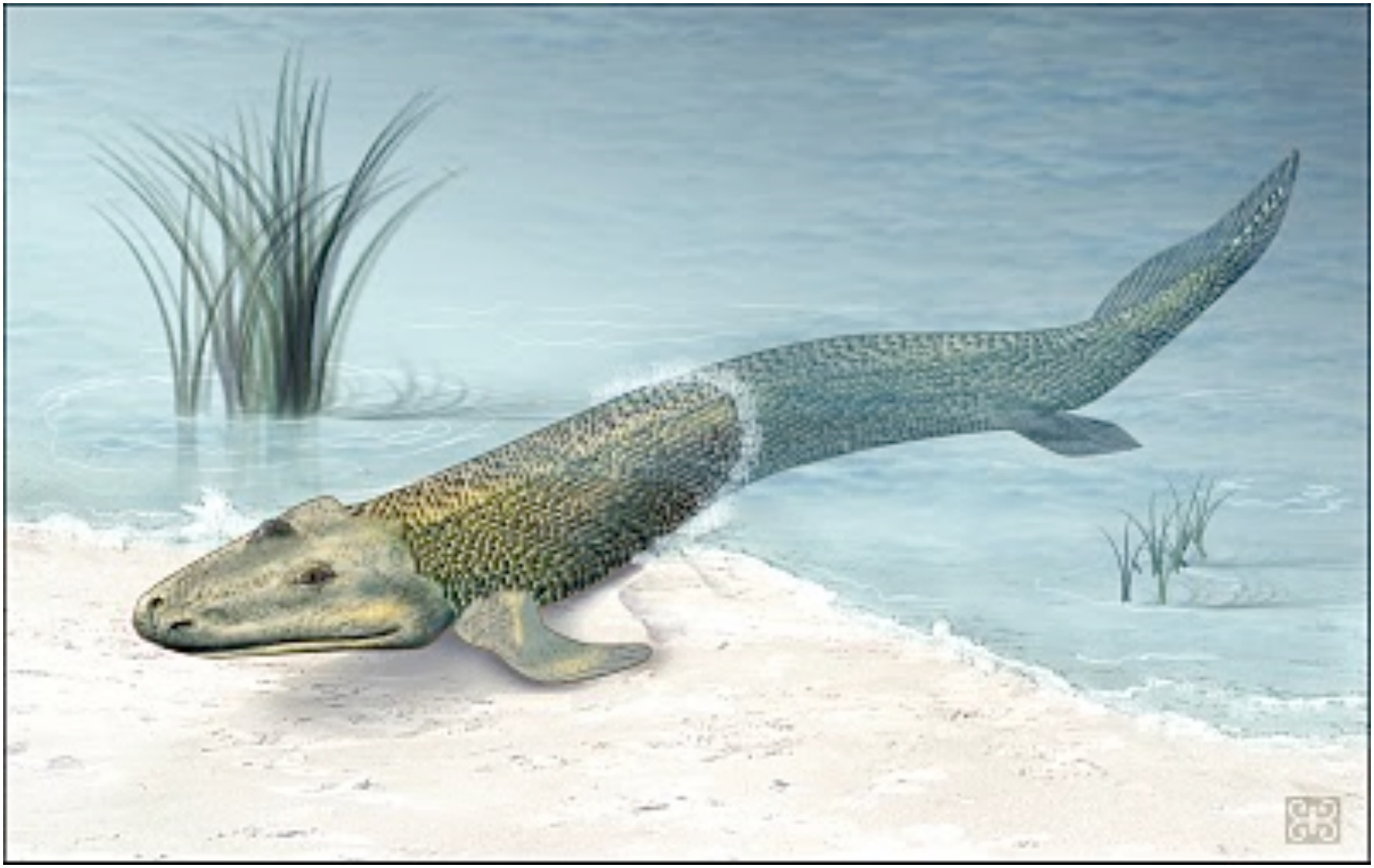
Where did reptiles and amphibians come from?



Things you might think about the transition to land

Legs evolved for locomotion on land

Lungs evolved for breathing on land



How do we learn about the origin of herps?

- Study relationships among living species
- Find and analyze fossils
- Understand genetics and development

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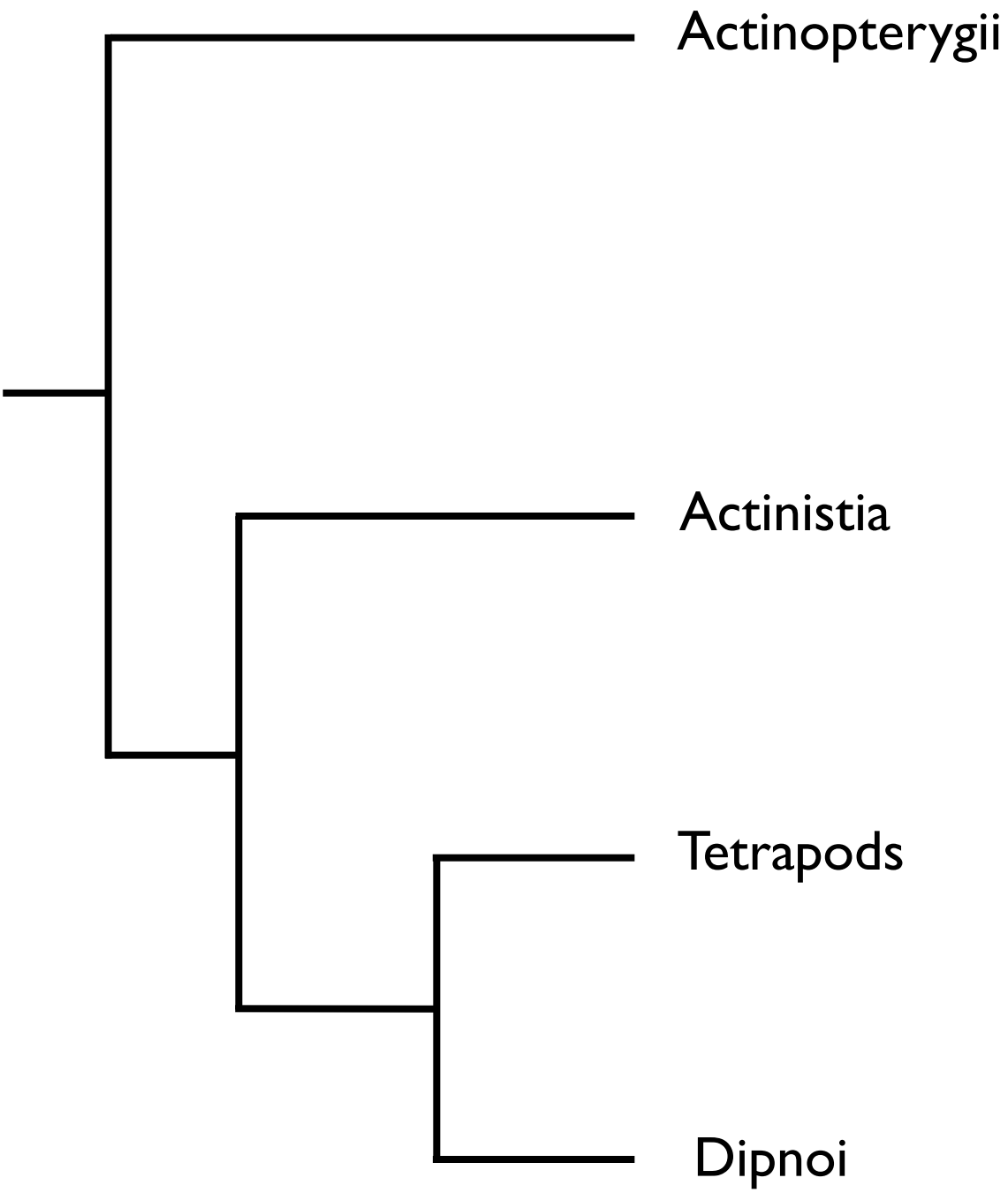
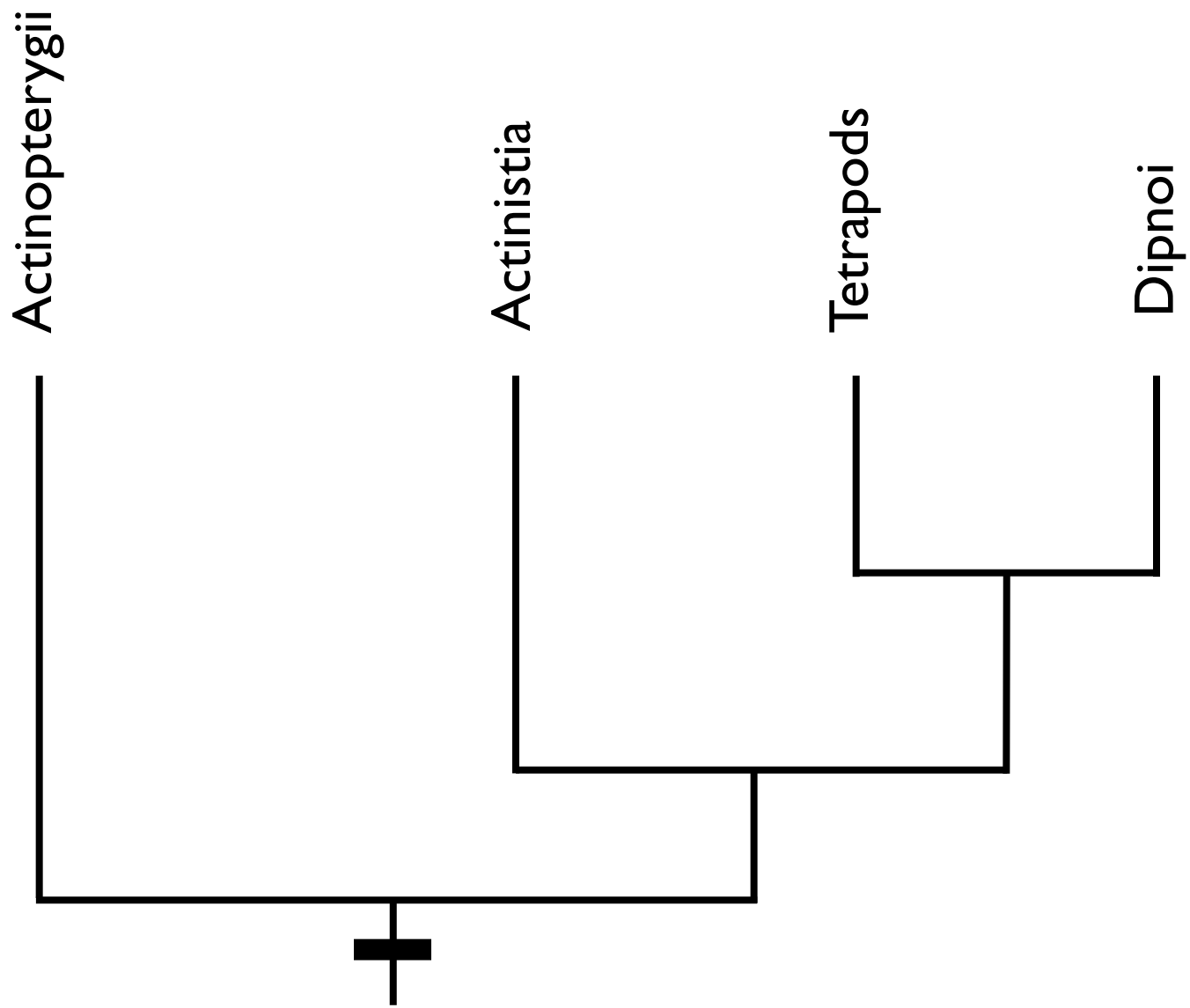
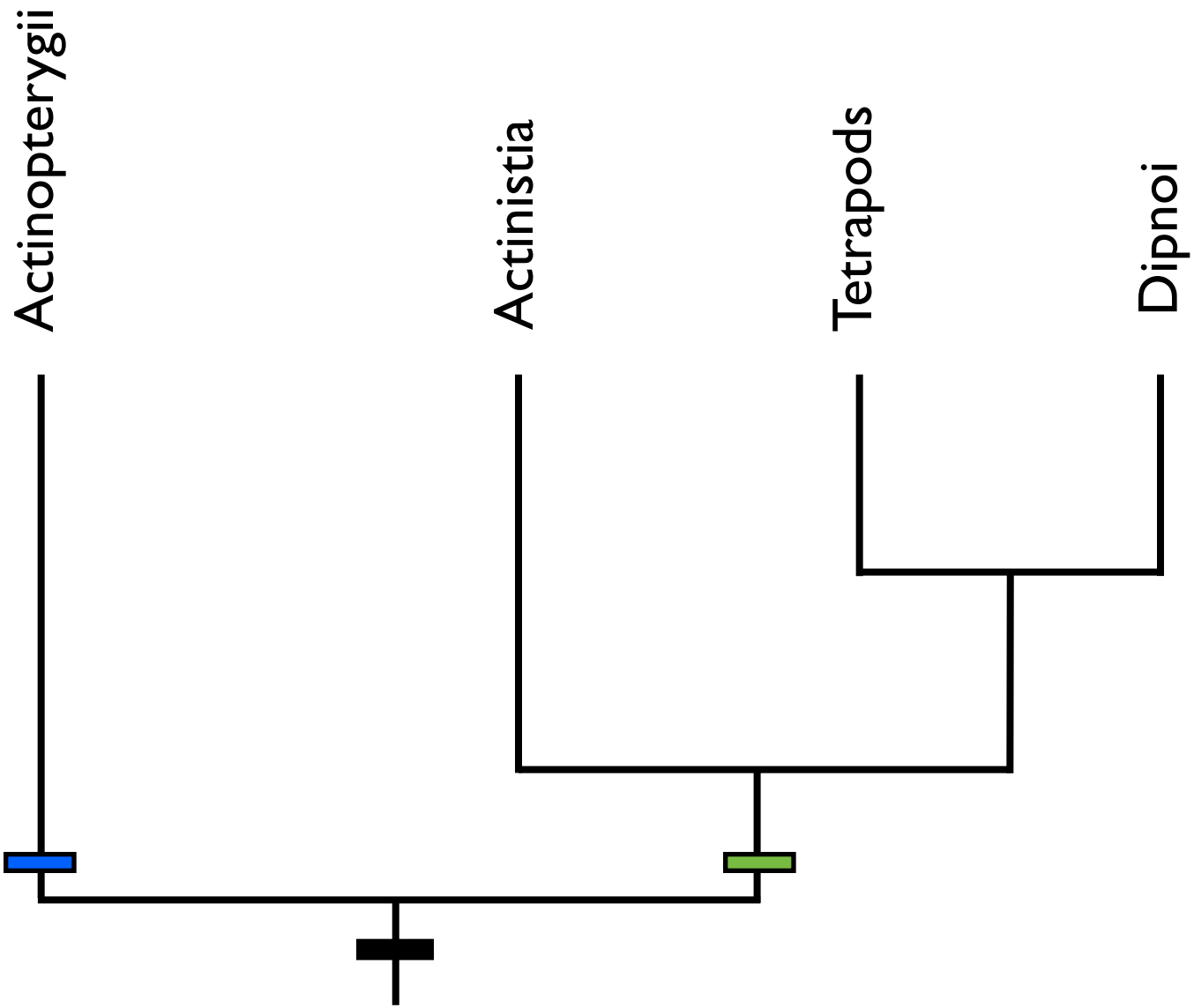

Actinopterygii
Actinistia
Tetrapods
Dipnoi

Osteichthyes (bony fishes)

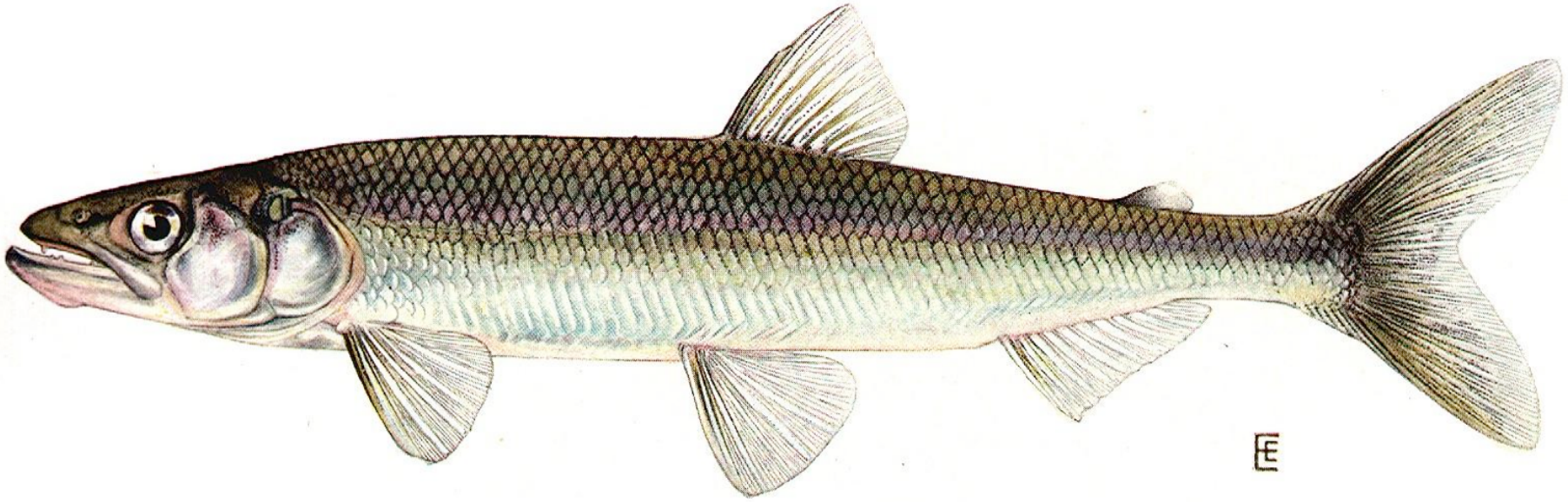


Osteichthyes (bony fishes)

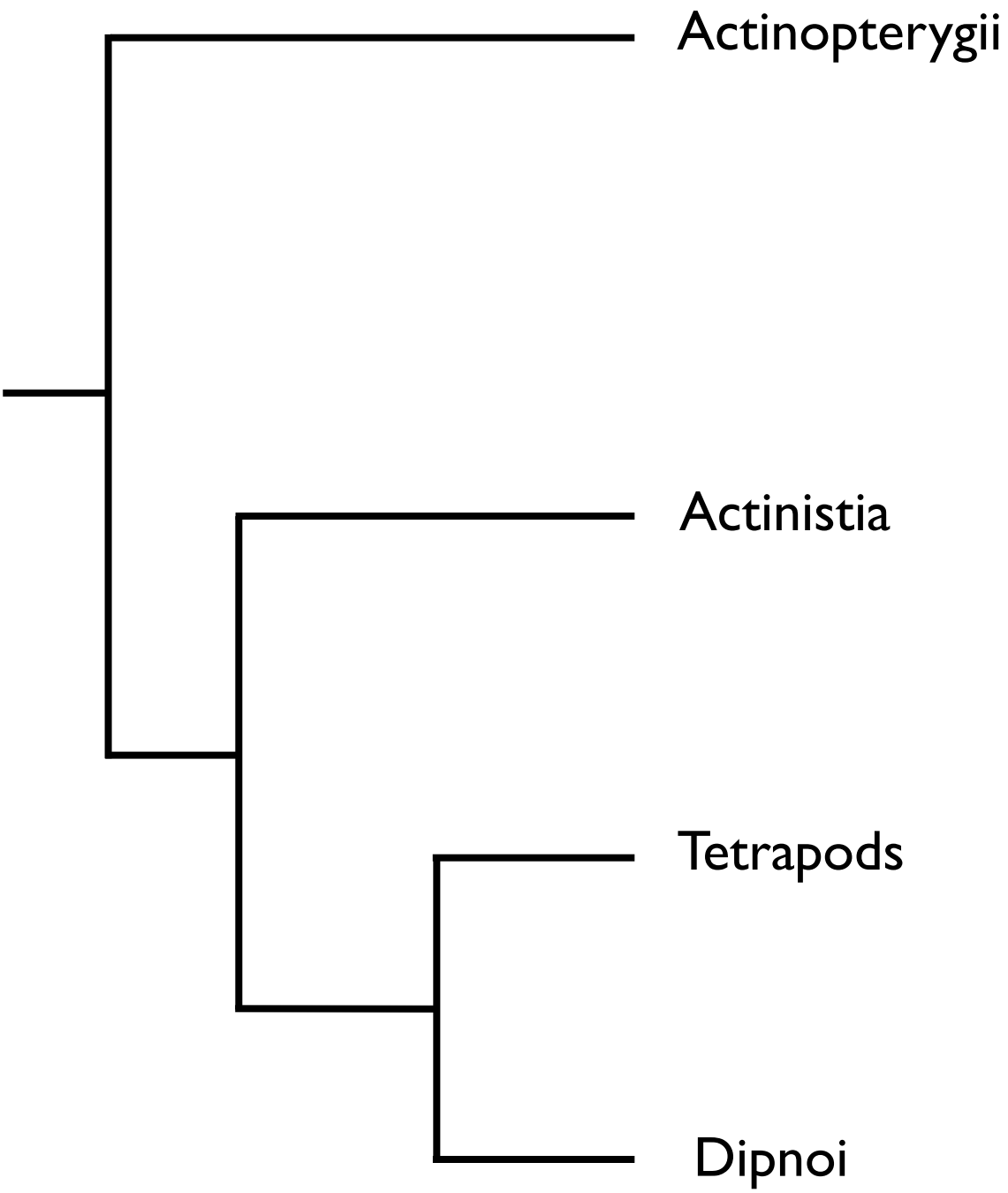
= Actinopterygii (ray-finned fishes) + Sarcopterygii (lobe-finned fishes)



Actinopterygii



ray-finned fishes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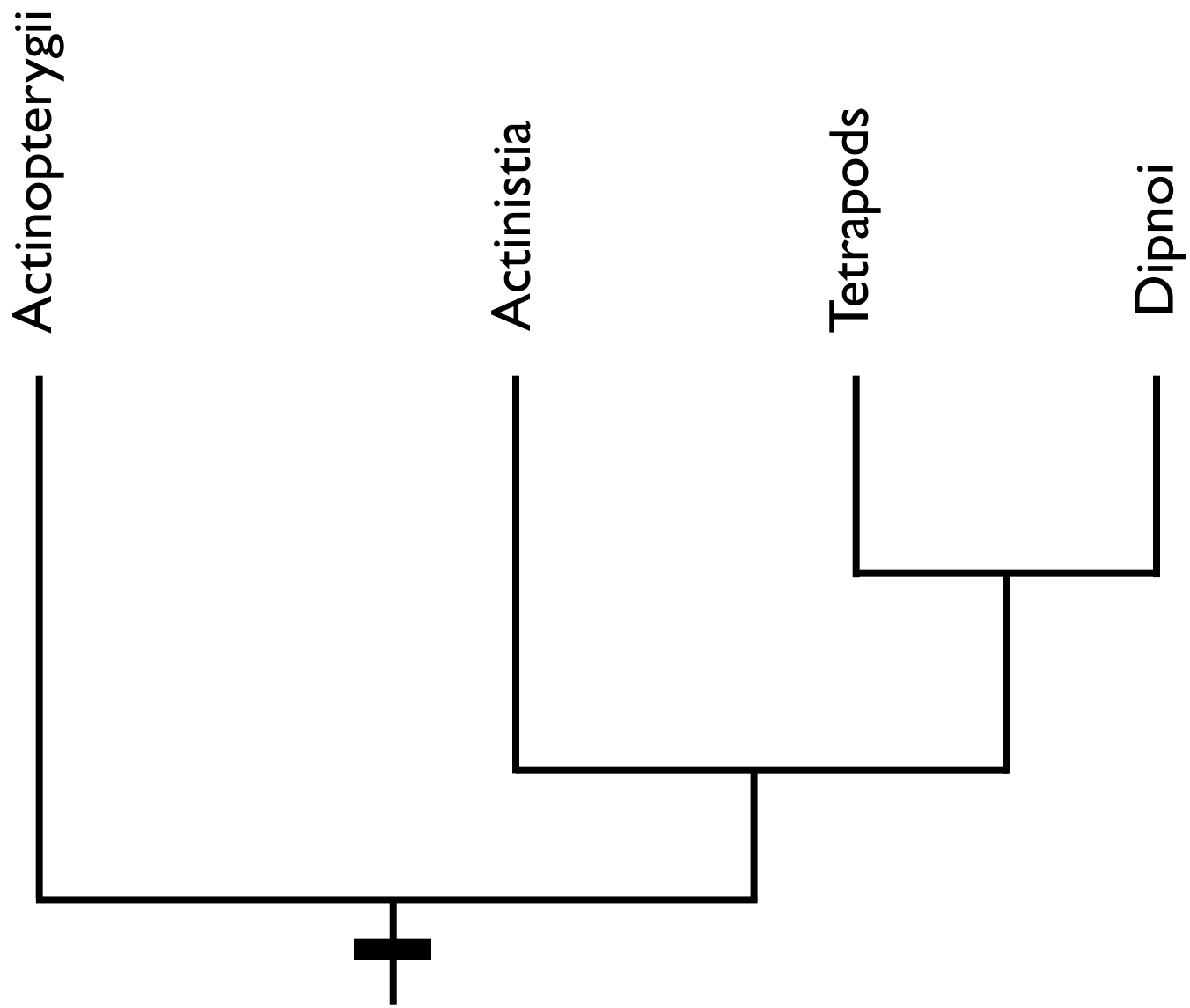
Osteichthyes (bony fishes)



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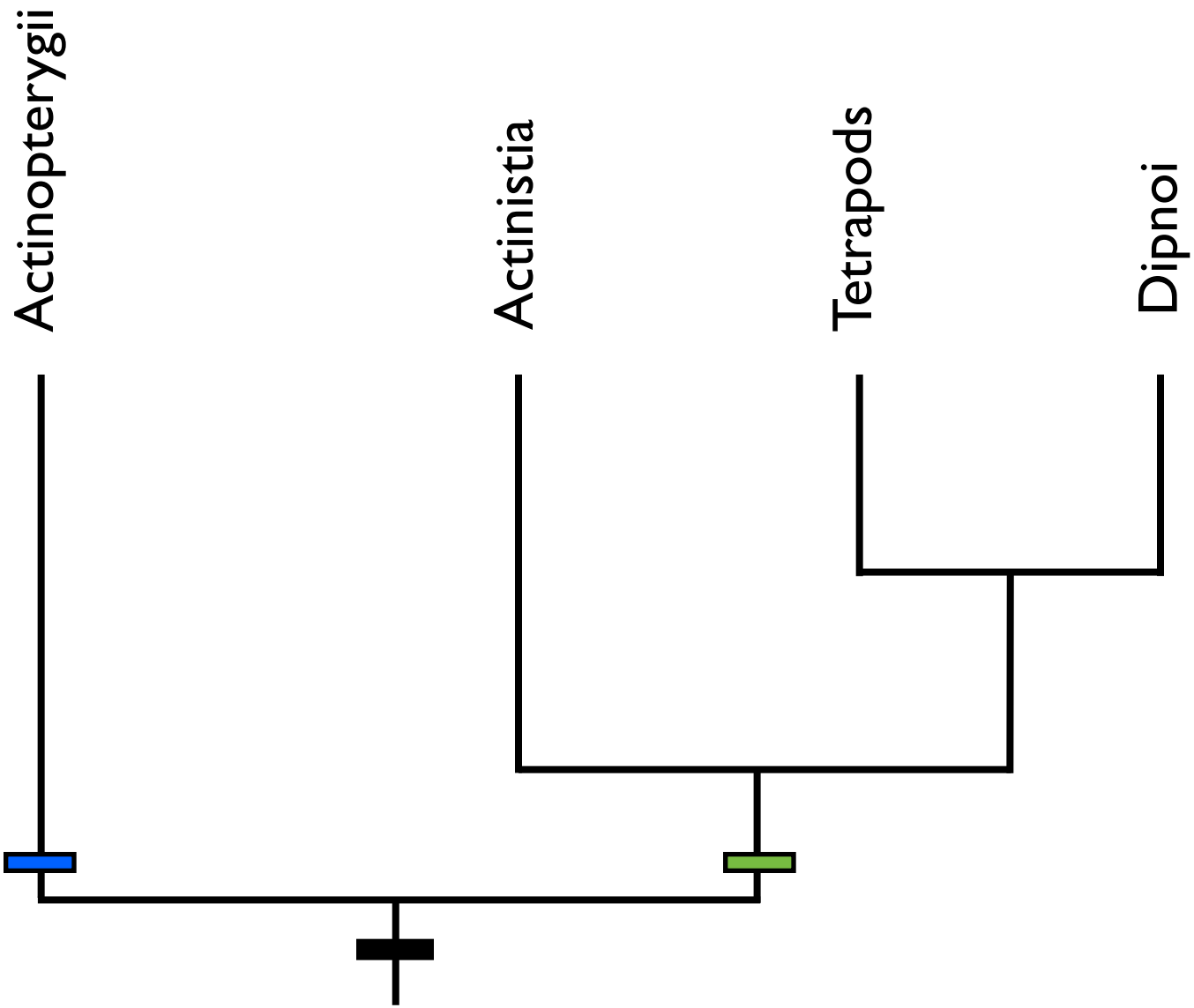

Actinistia


Actinistia
92-73007A


Coelacanth

Dipnoi

lungfish

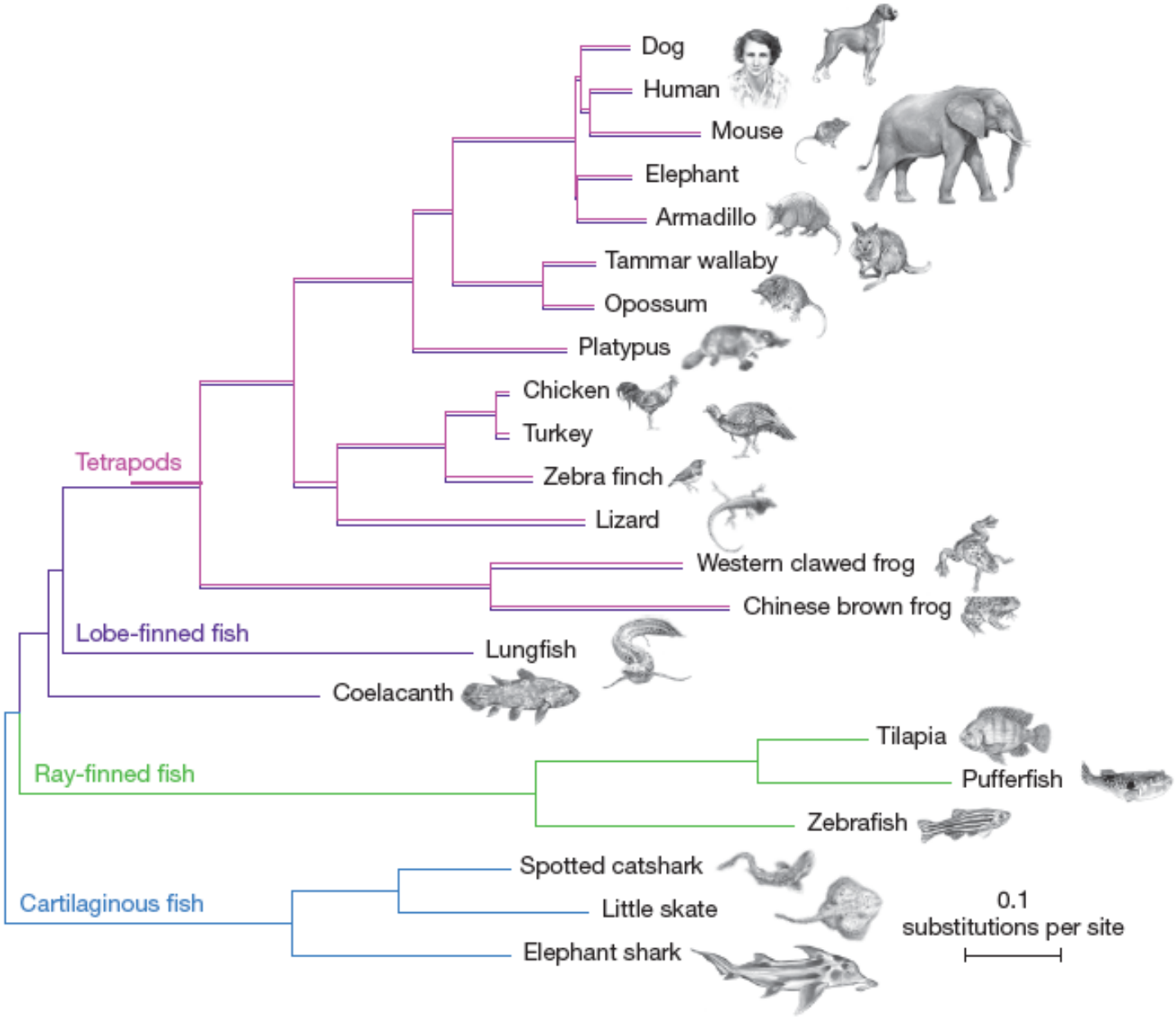

Figure 1 | A phylogenetic tree of a broad selection of jawed vertebrates shows that lungfish, not coelacanth, is the closest relative of tetrapods.

Amemiya et al 2013

NATIONAL GEOGRAPHIC

Find more wallpapers at **www.nationalgeographic.com**

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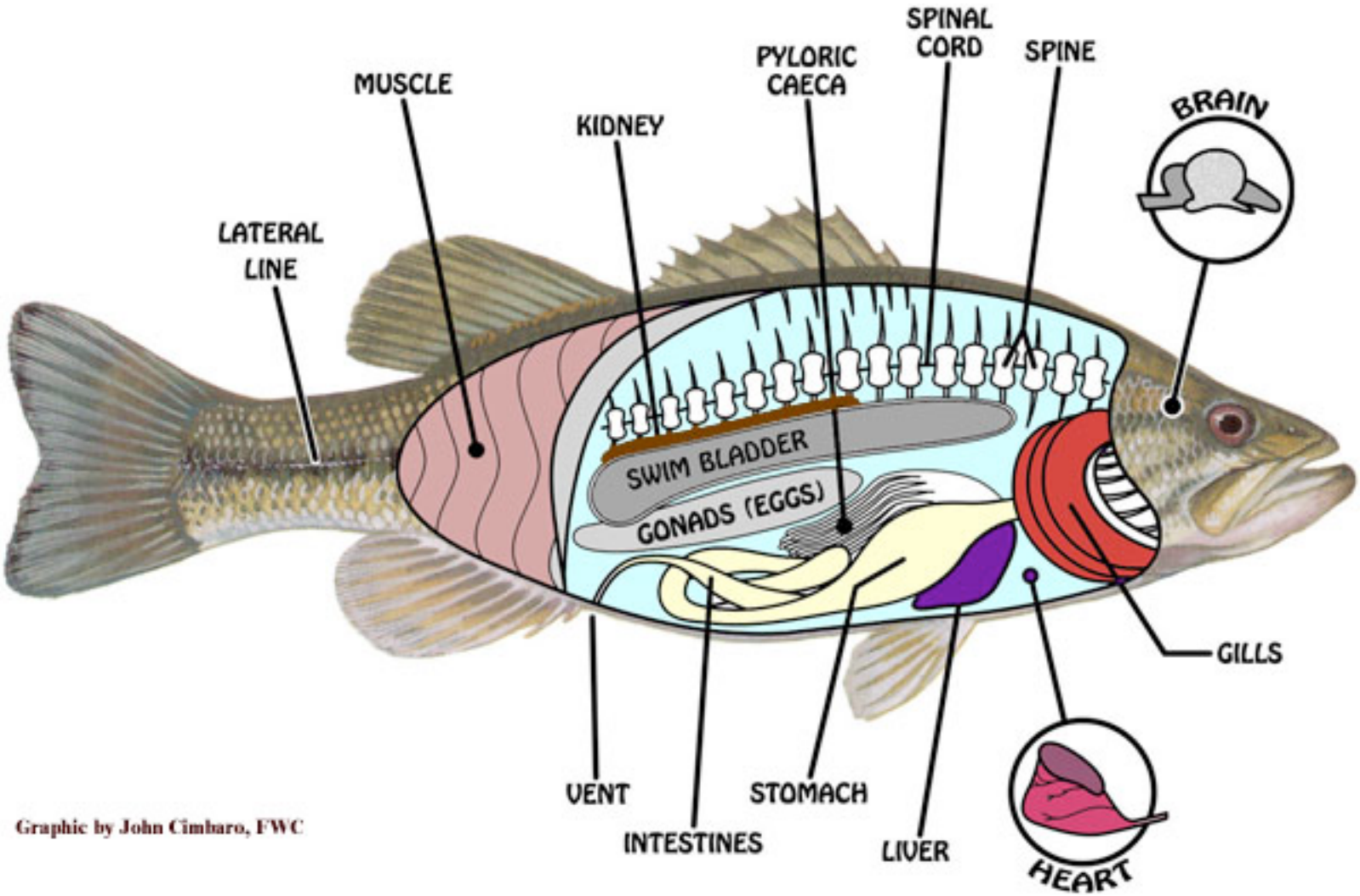
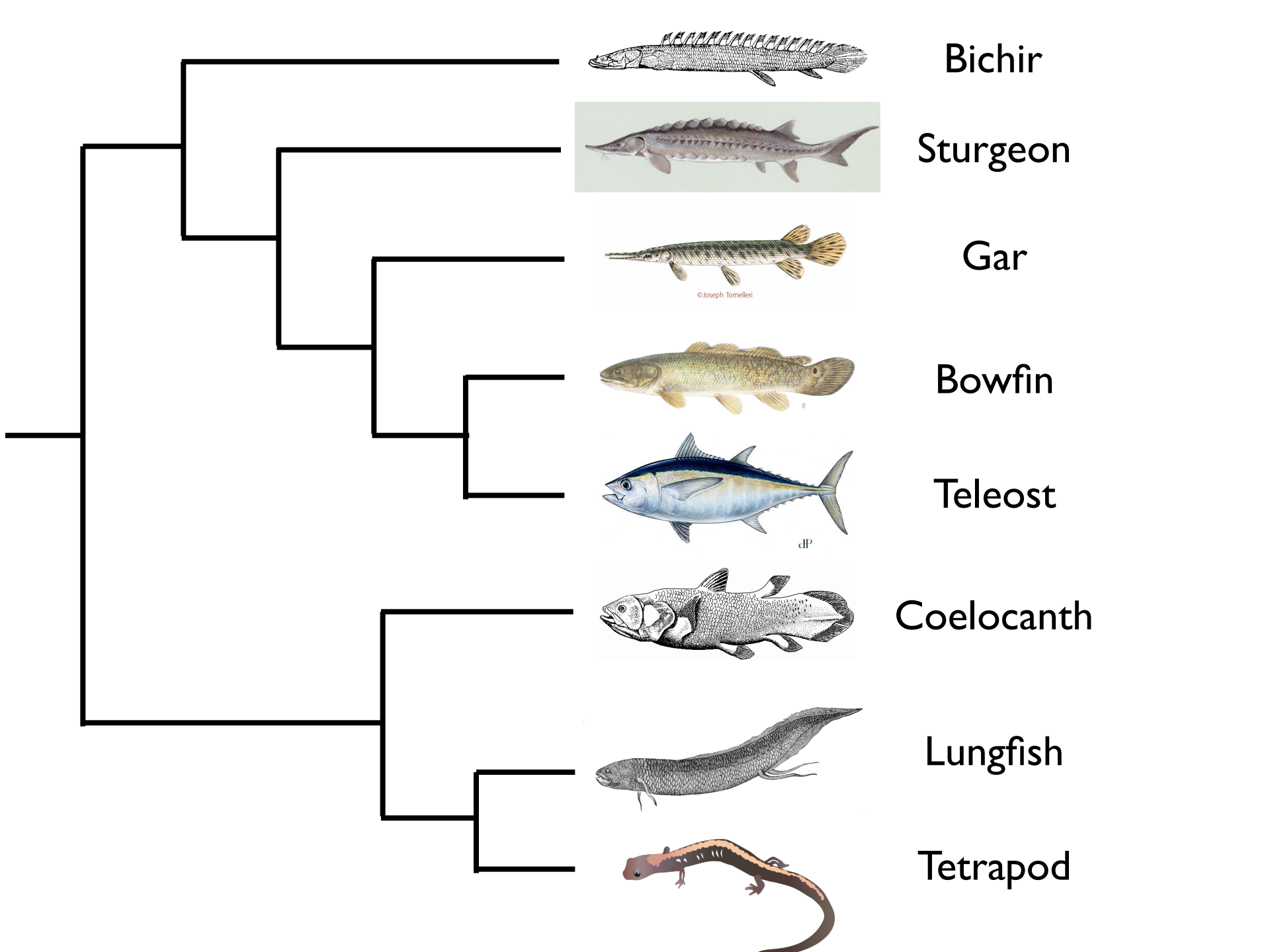
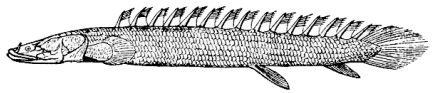
Photograph by Tim Laman


SPINAL CORD
PYLORIC CAECA
SPINE
MUSCLE
KIDNEY
BRAIN
LATERAL LINE
SWIM BLADDER
GONADS (EGGS)
GILLS
VENT
STOMACH
INTESTINES
LIVER
HEART
Graphic by John Cimbaro, FWC


Bichir
Sturgeon
Gar
©Joseph Tomelleri
Bowfin
Teleost
dP
Coelocanth
Lungfish
Tetrapod



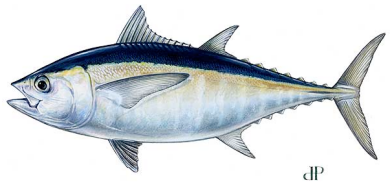
Bichir

Sturgeon

swim bladder

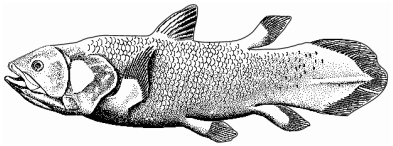
Gar

Bowfin

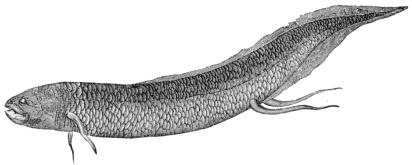


Teleost

swim bladder

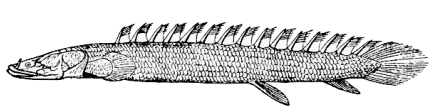


Coelocanth



Lungfish

Tetrapod



Bichir

lungs

Sturgeon

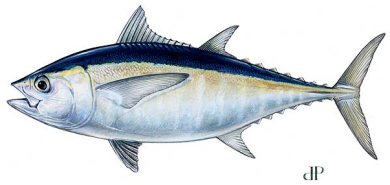
swim bladder

Gar

swim bladder as lung

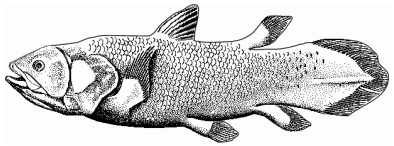
Bowfin

swim bladder as lung



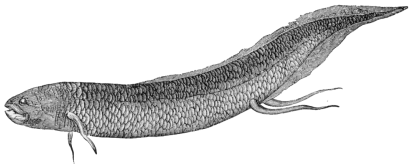
Teleost

swim bladder



Coelocanth

"fatty lung"

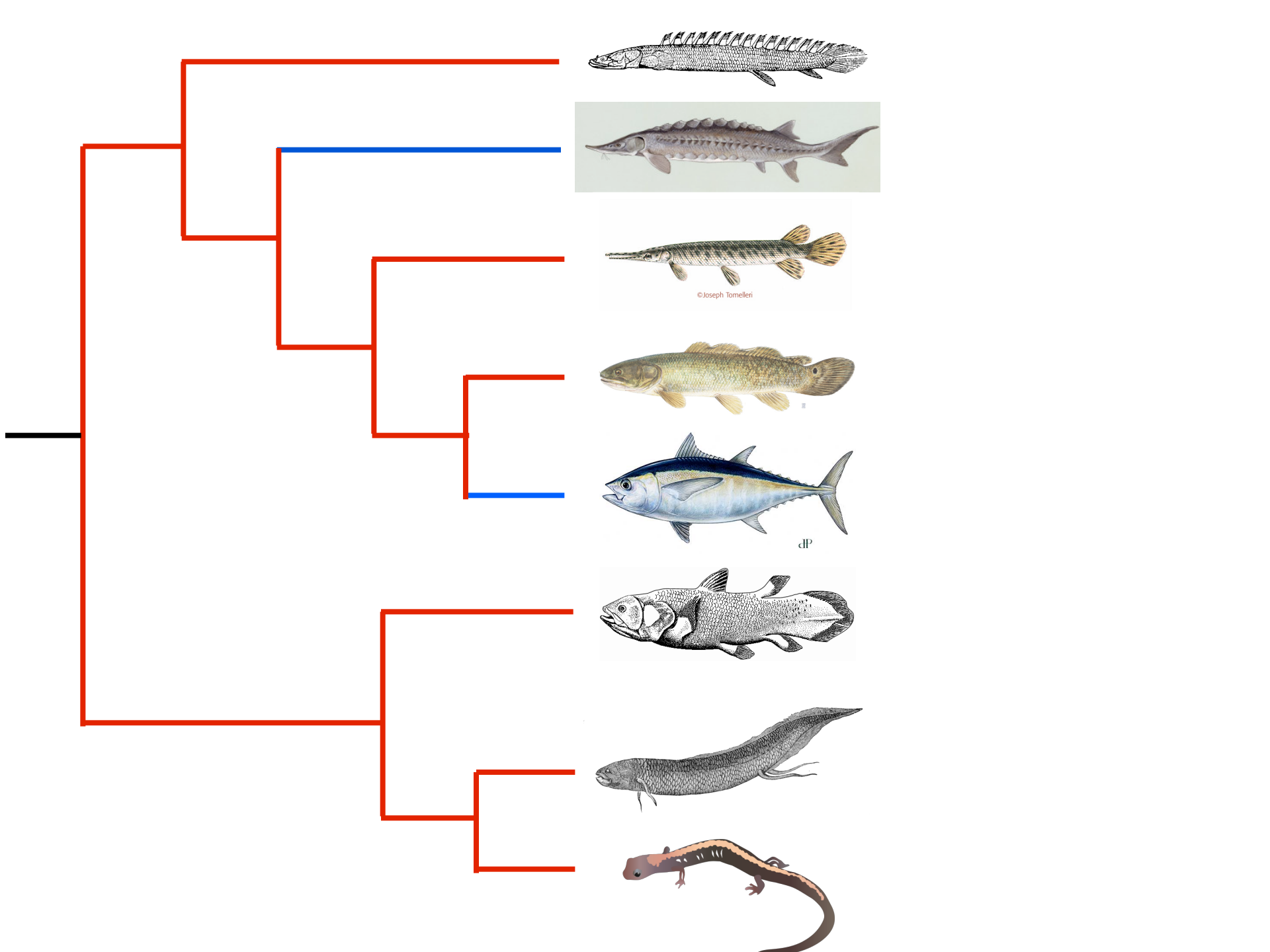


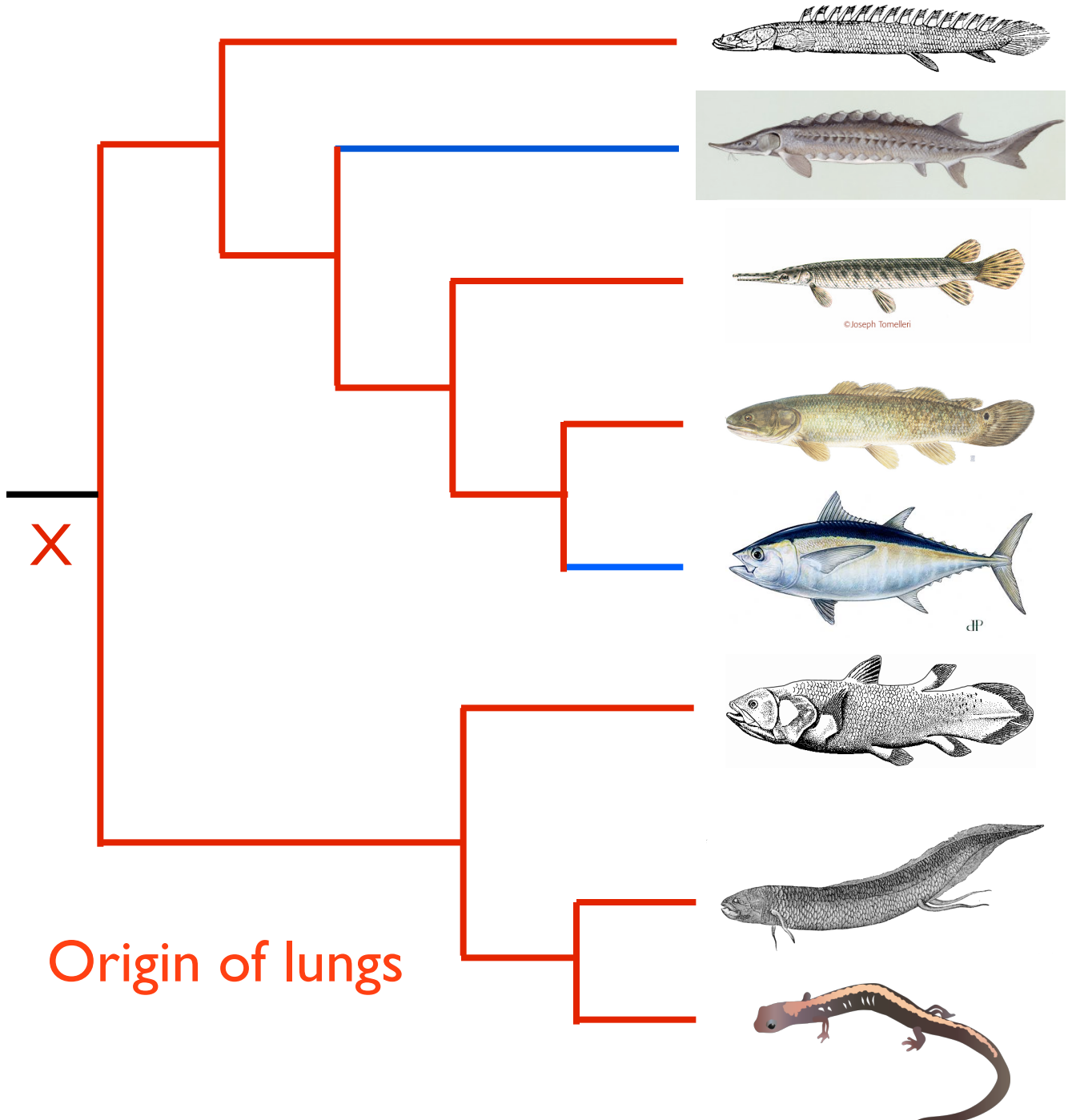
Lungfish

lungs

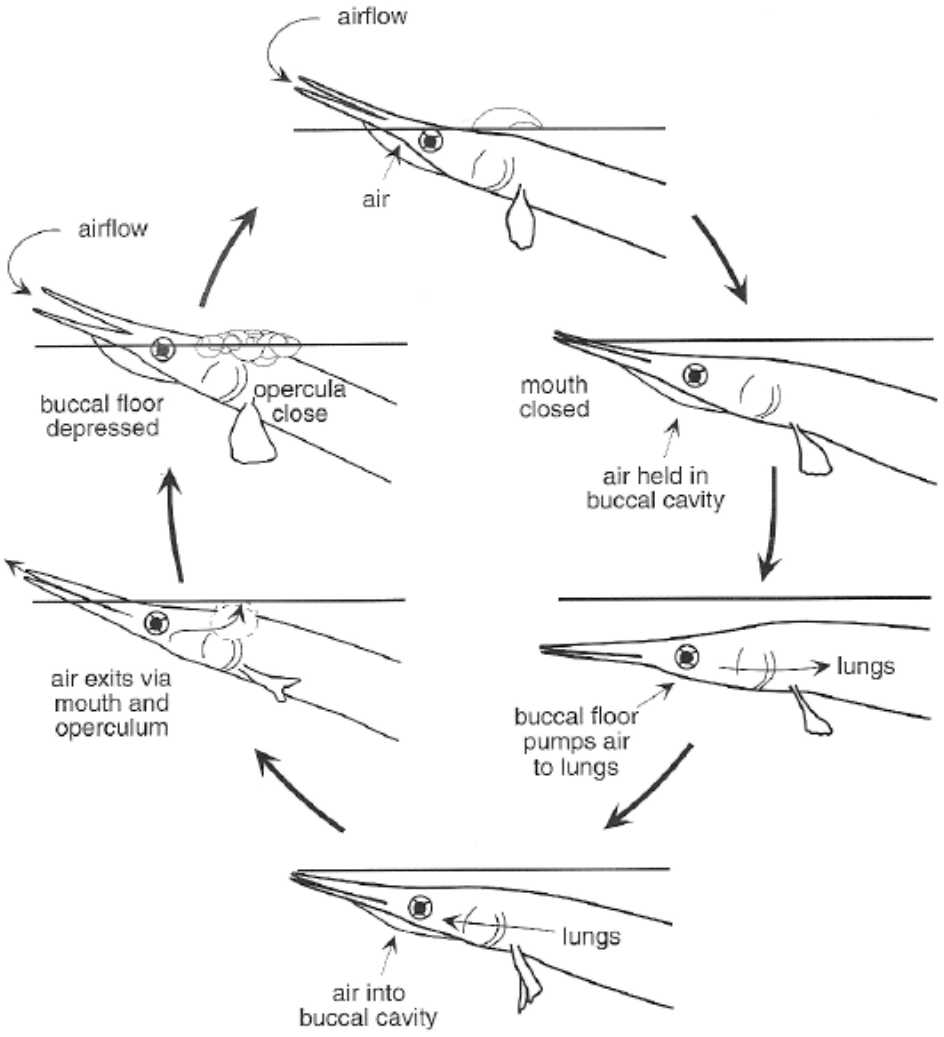
Tetrapod

lungs


©Joseph Tomelleri
dP


X
Origin of lungs
©Joseph Tomelleri
dP

Lungs in the Water



Air breathing cycle in the long-nosed Gar; from Zar et al.

Things you might think about the transition to land

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- Study relationships among living species
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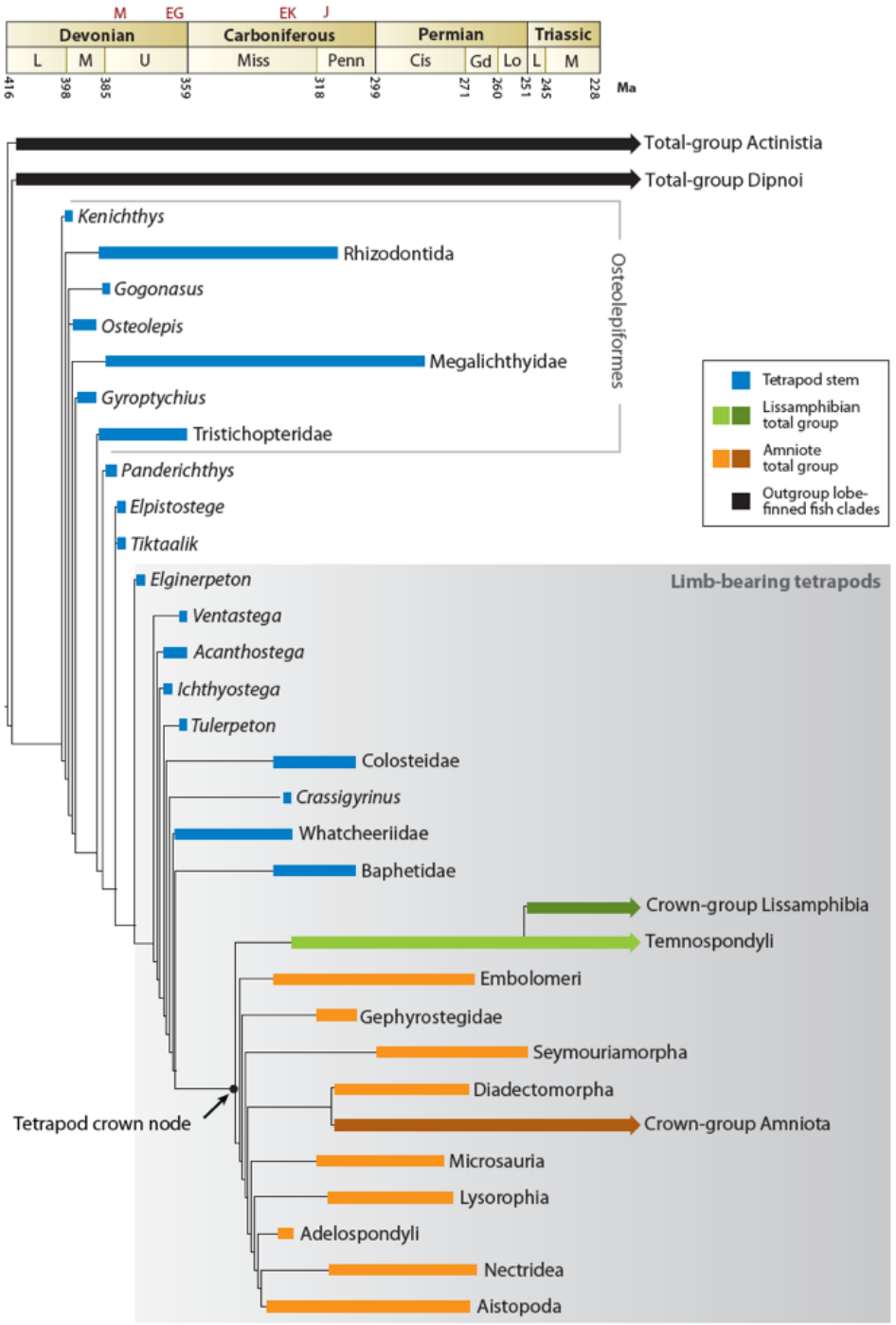
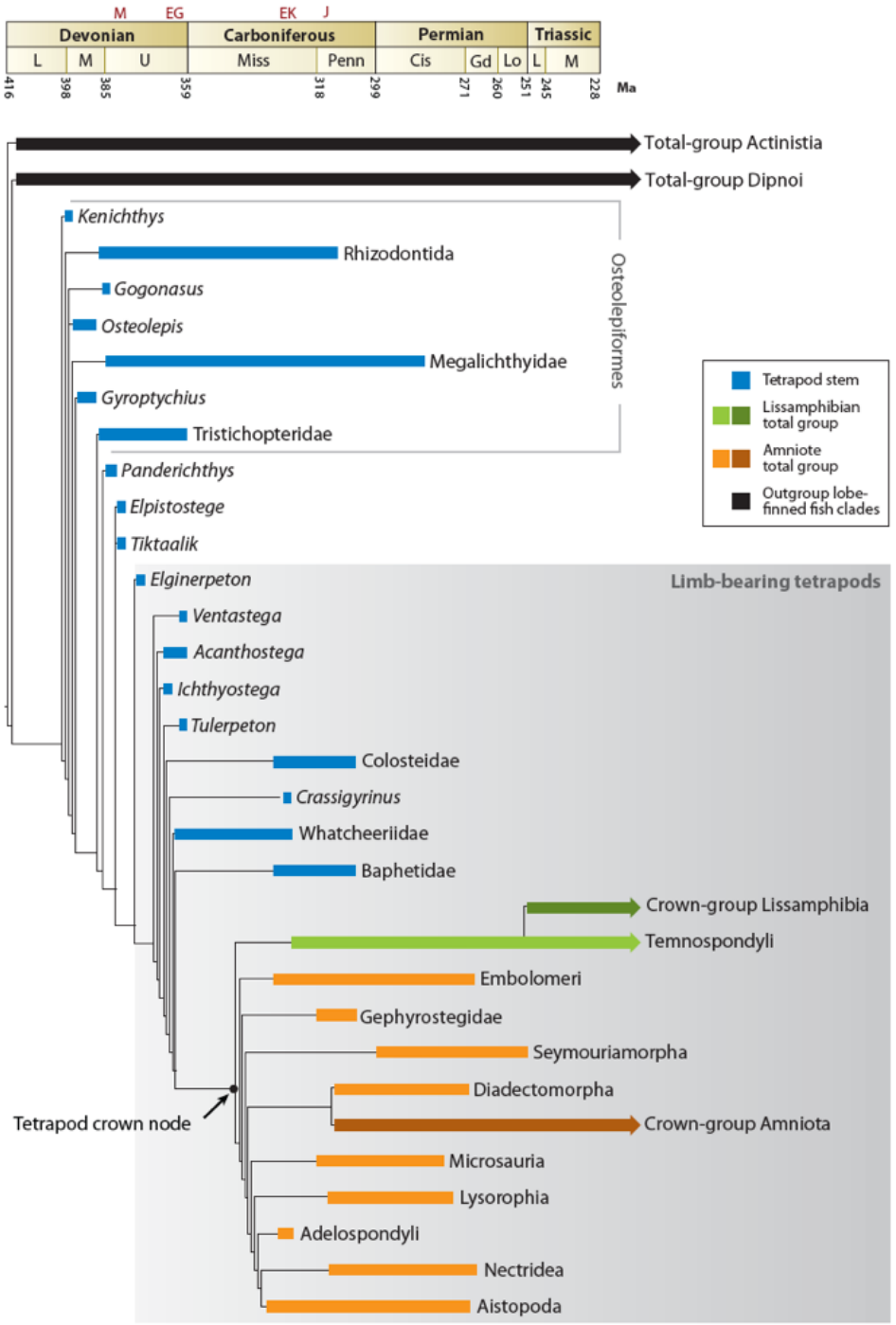
Coates et al. 2008

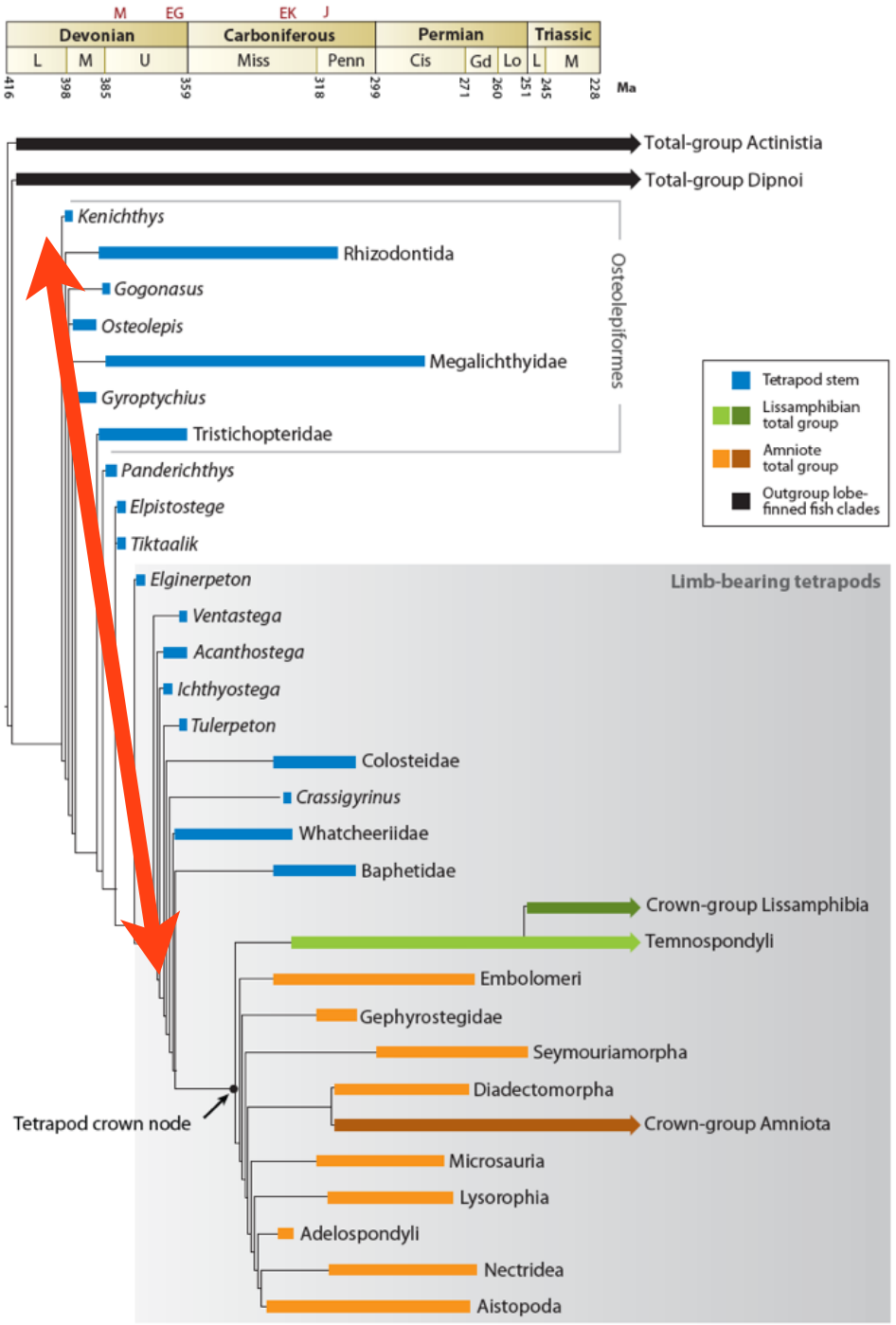


Coates et al. 2008

There are hundreds of fossil taxa that document the transition from lobe-finned fish, to tetrapods, and then to amphibians, reptiles, and mammals



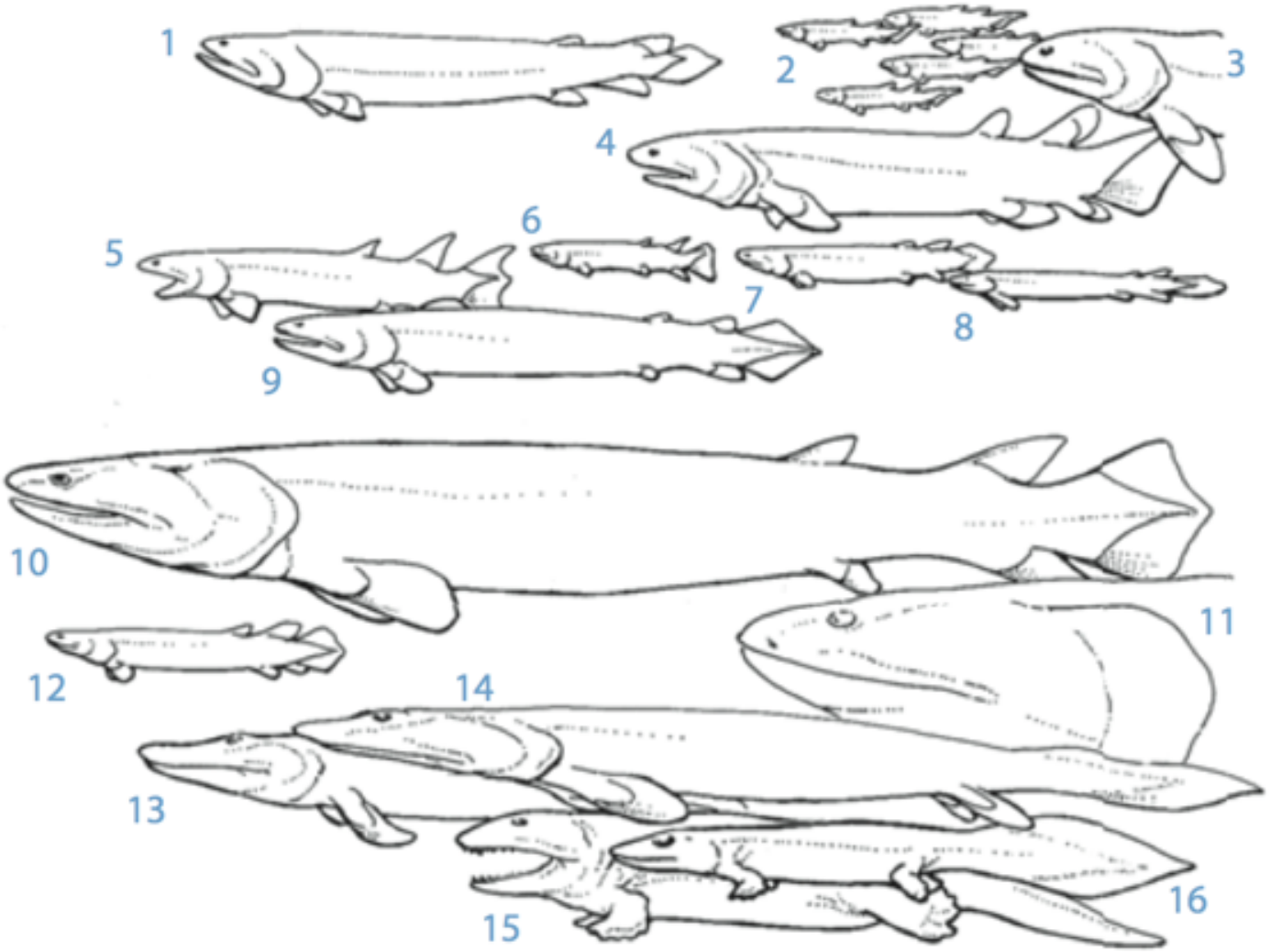
Coates et al. 2008

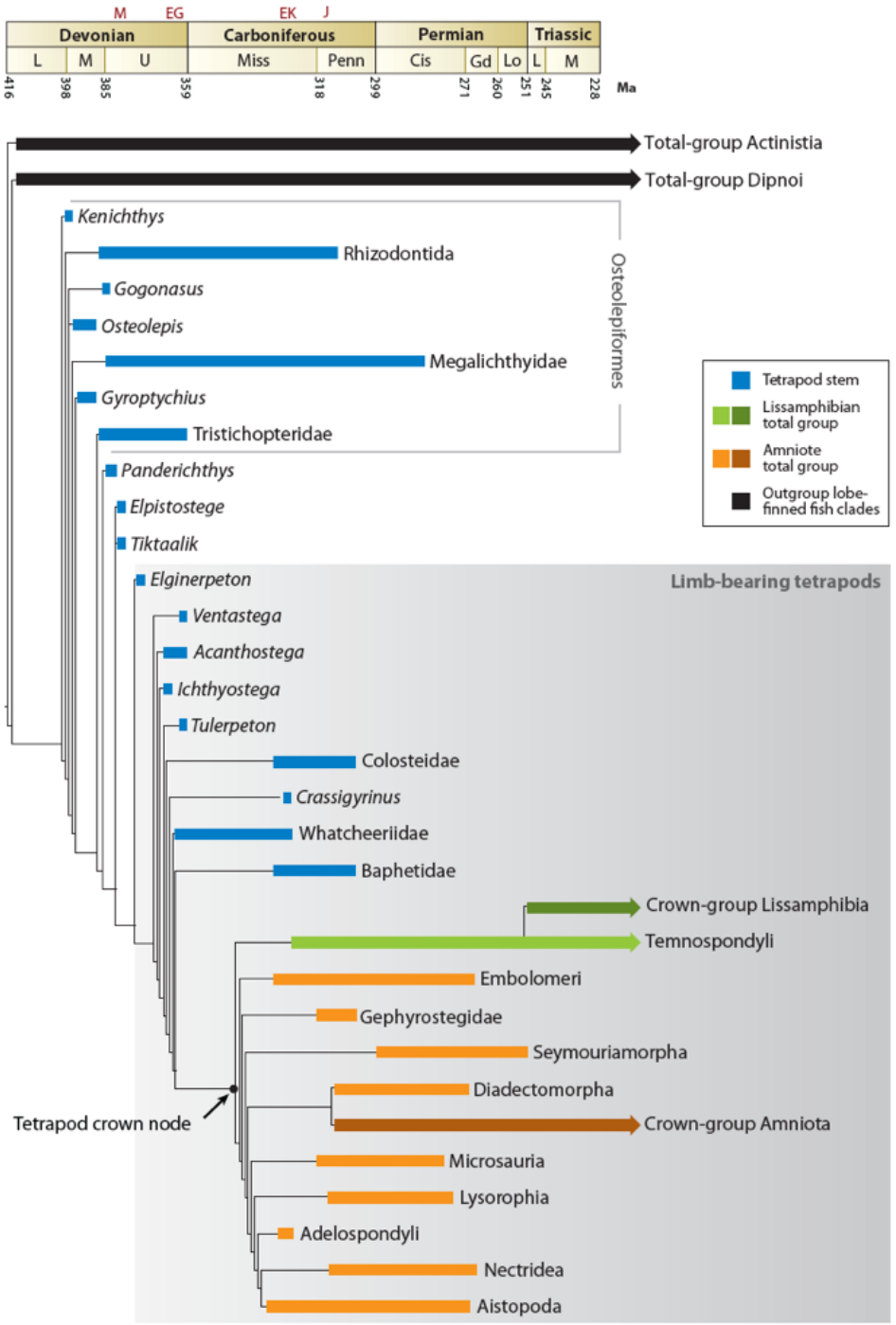


Coates et al. 2008

Lineages from the “tetrapod stem”
tell the tale of the emergence of tetrapods

Devonian tetrapods





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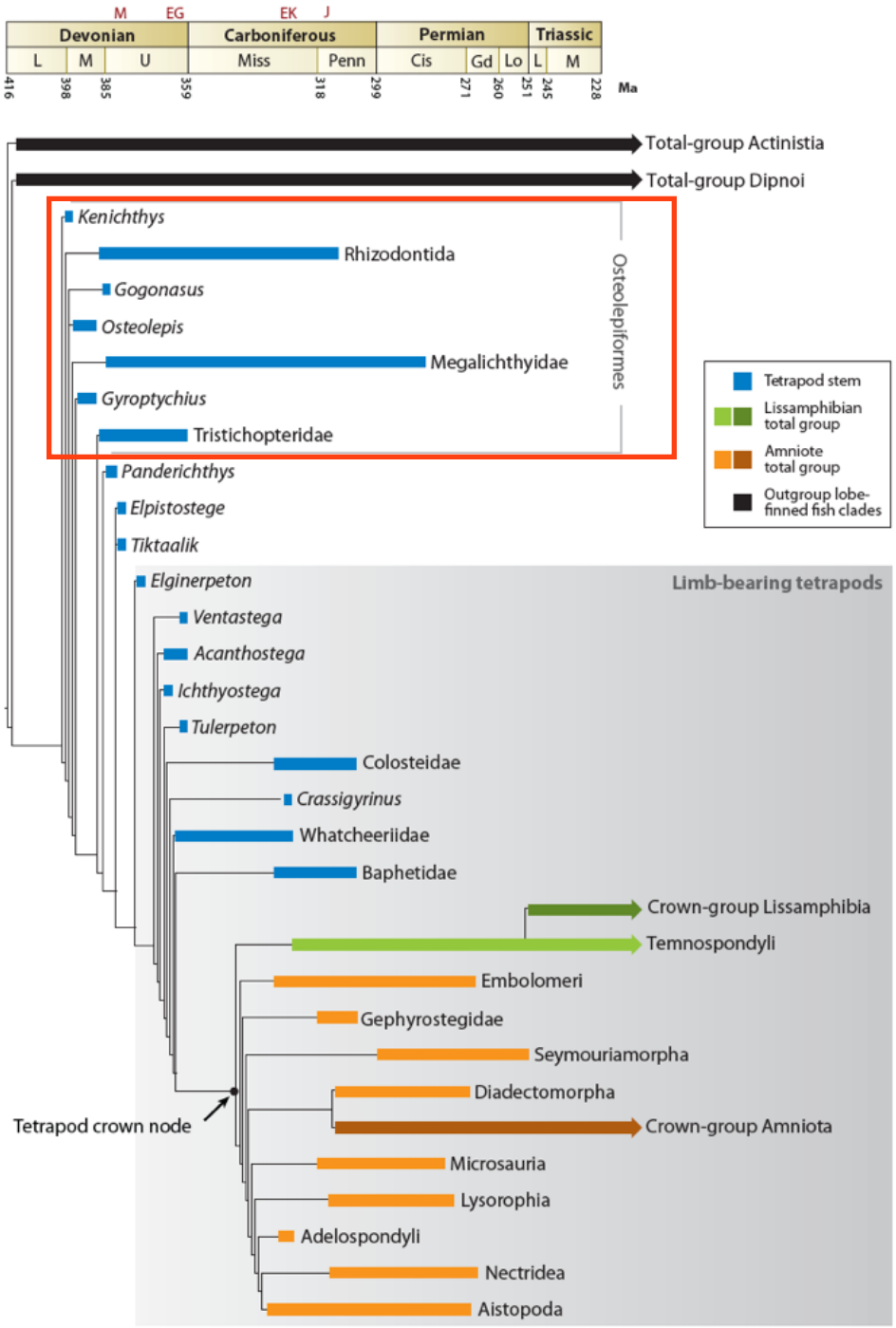


Coates et al. 2008

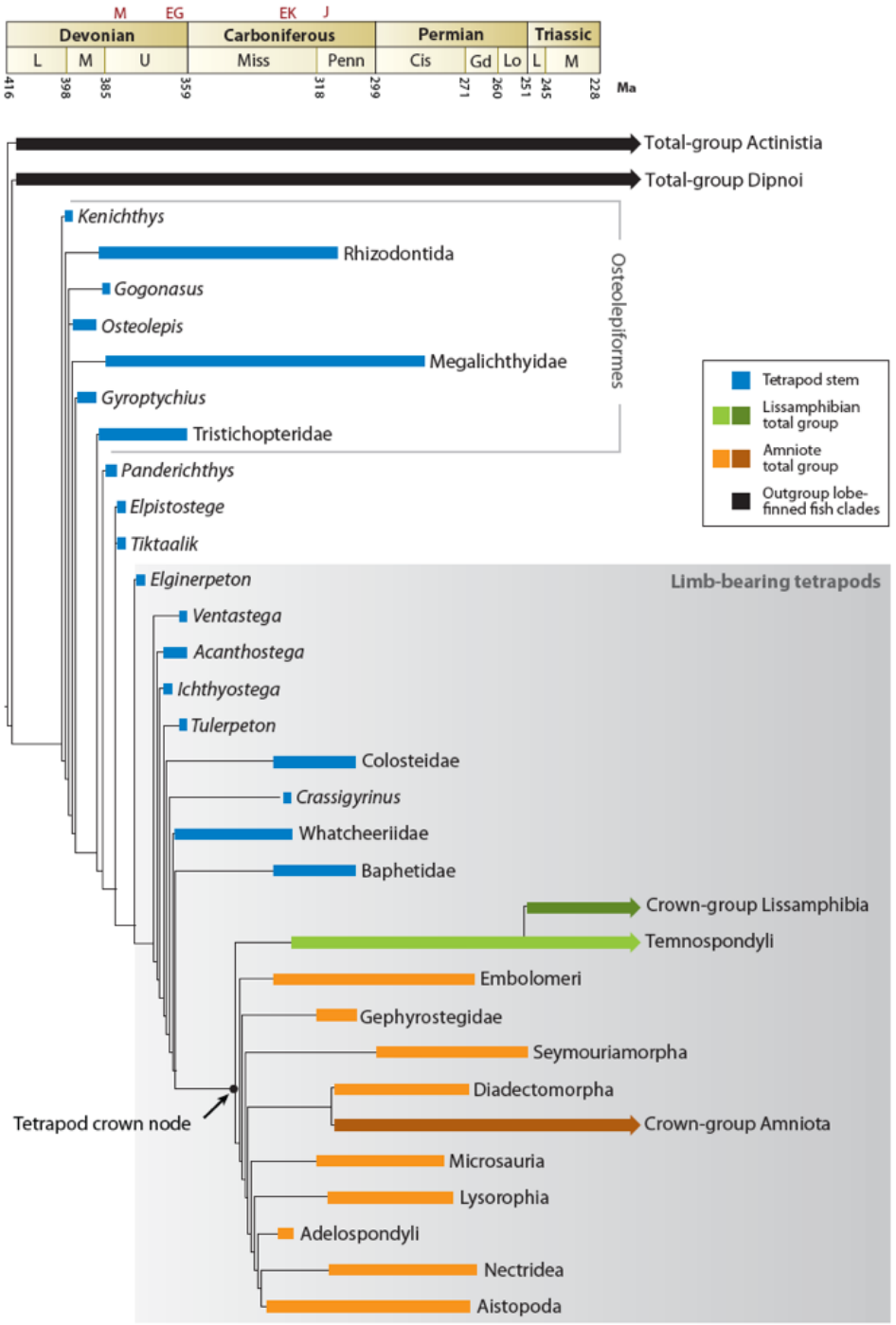
Osteolepiformes

Osteolepis

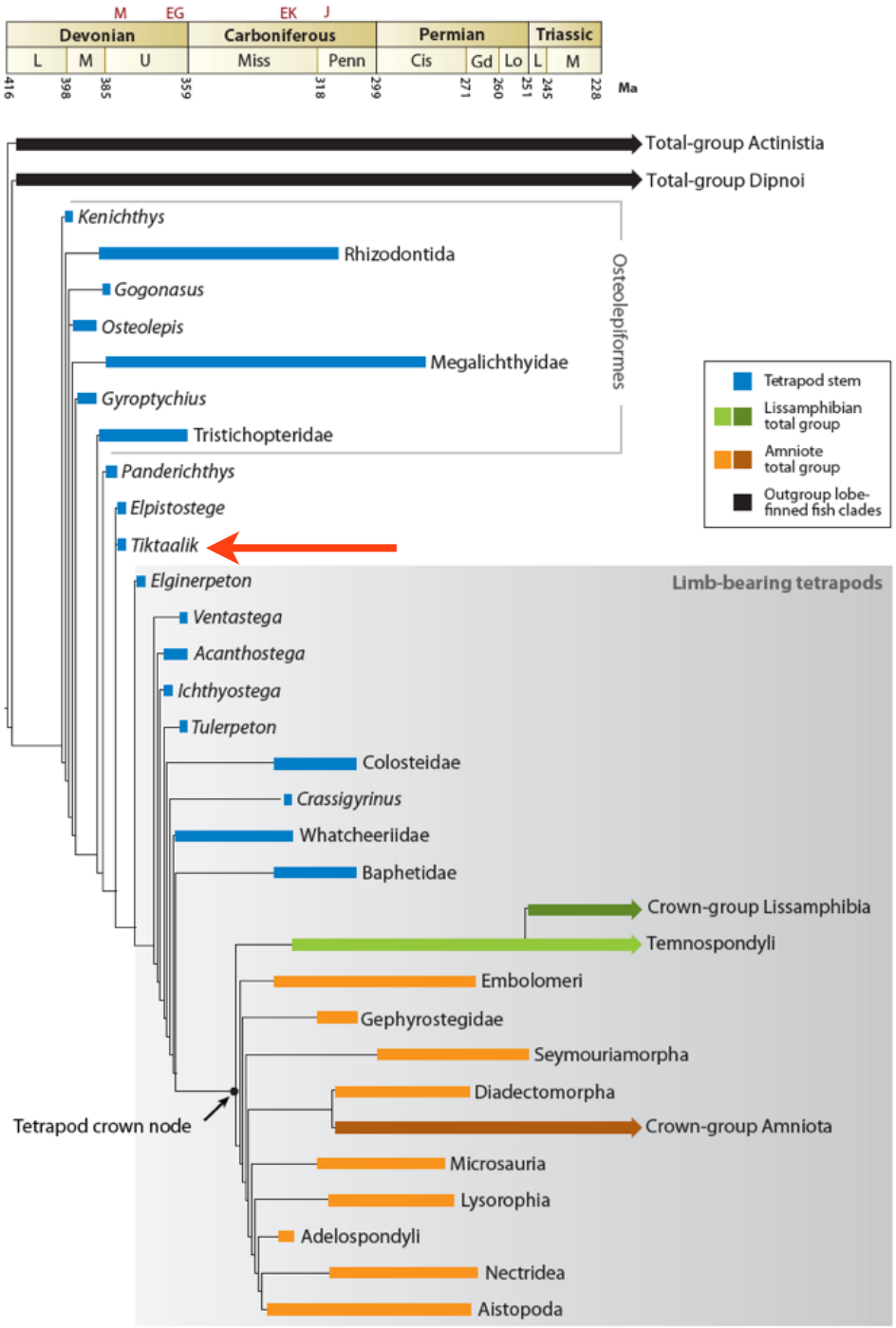
ancient lobe-finned fishes

Nobu Tamura (http://spinops.blogspot.com)


Eusthenopteron



Coates et al. 2008



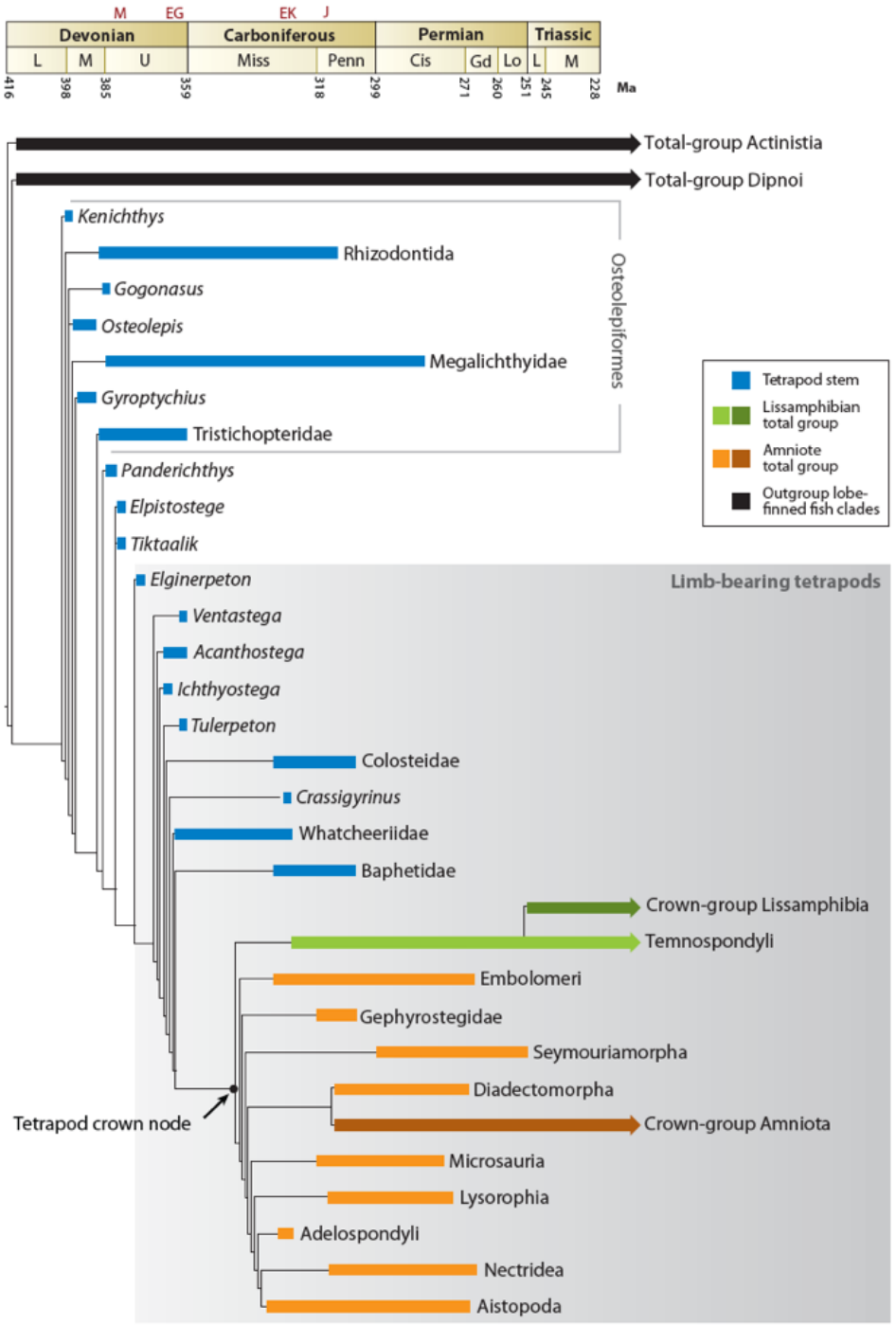
Coates et al. 2008

Tiktaalik

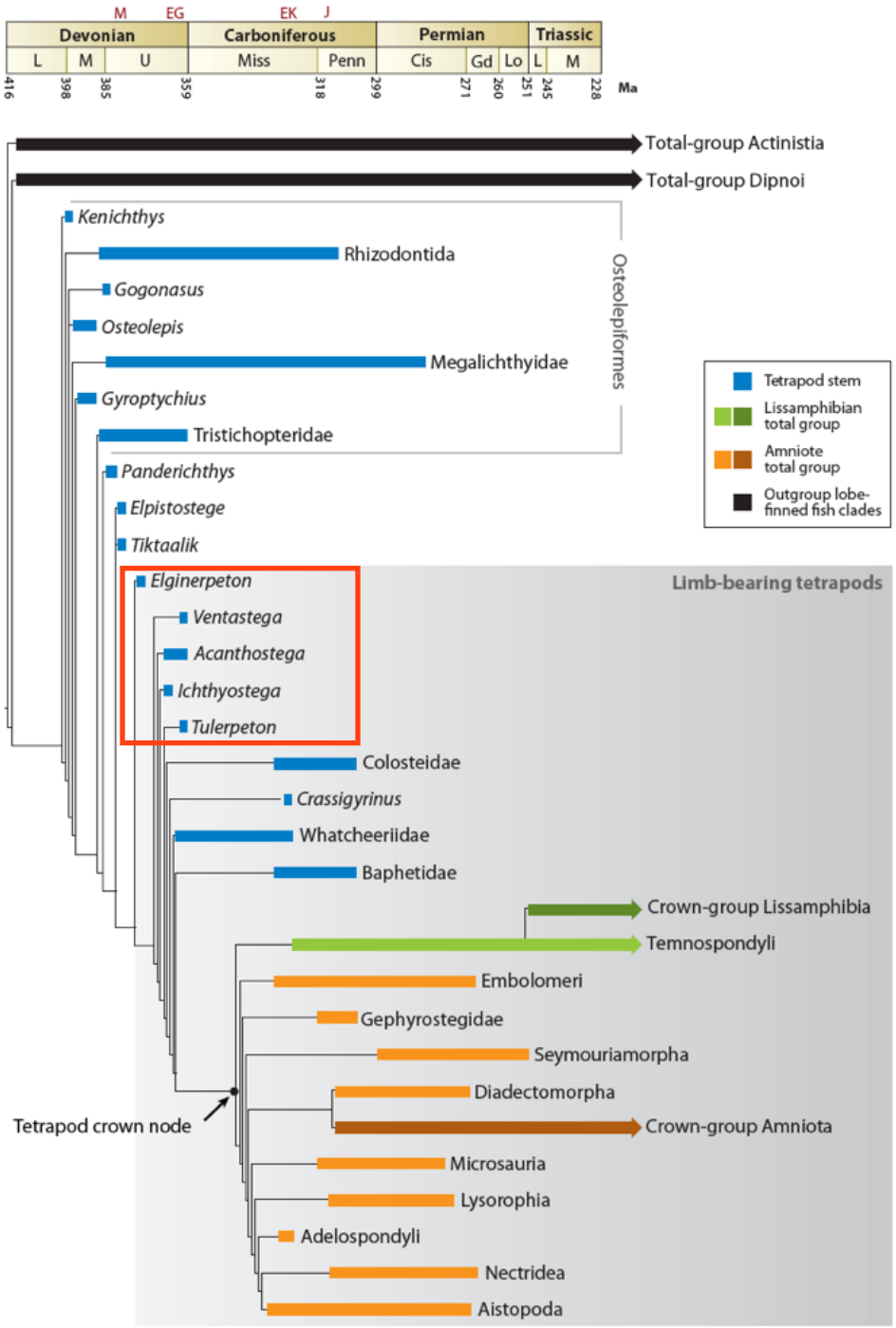
Tiktaalik could paddle & do push-ups...

Fin as a Paddle

Fin as a Prop

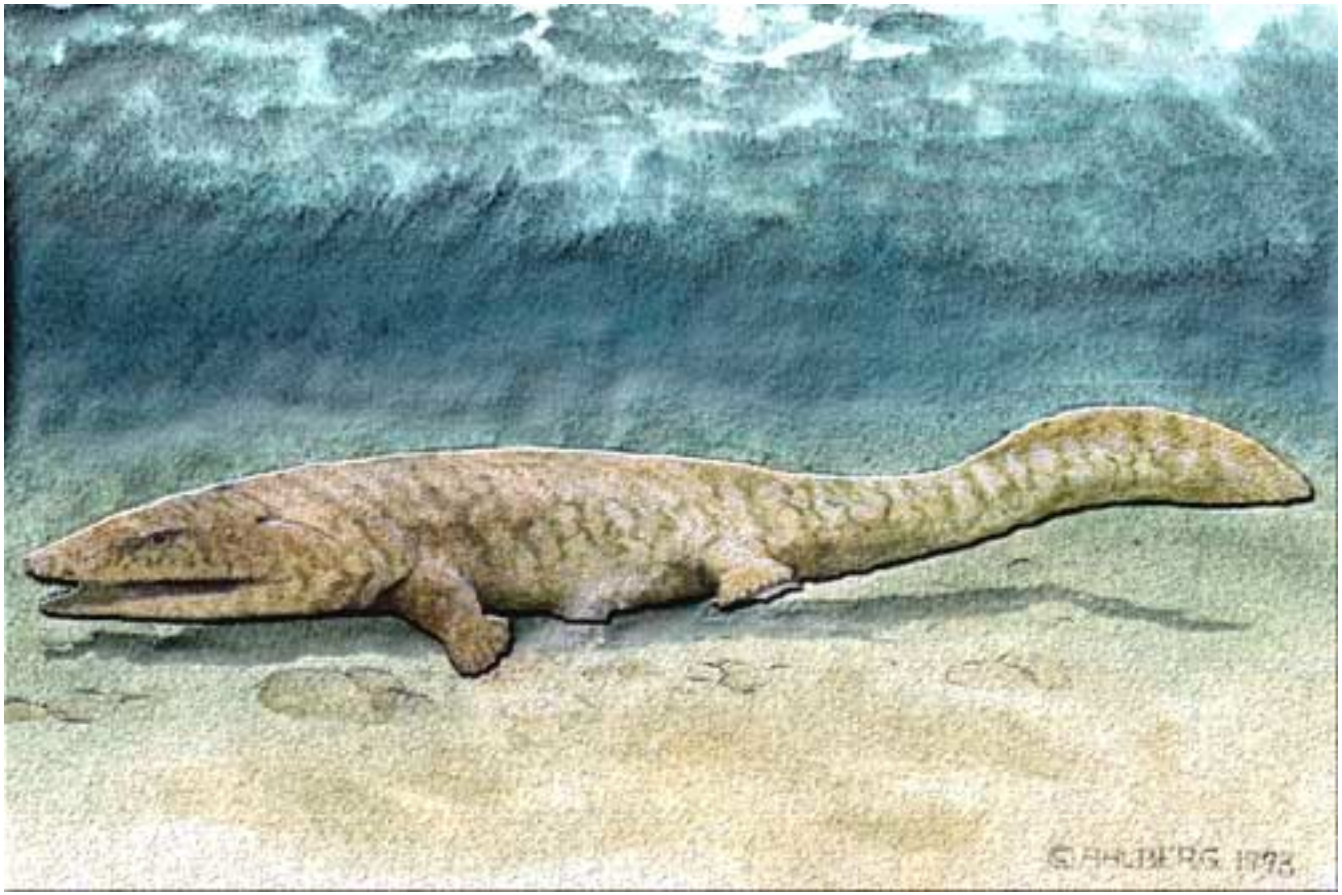


Coates et al. 2008



Coates et al. 2008

early limb-bearing tetrapods



Elginerpeton

– 370-364 mya

– Earliest known limbed tetrapod

Per Albergh

Acanthostega

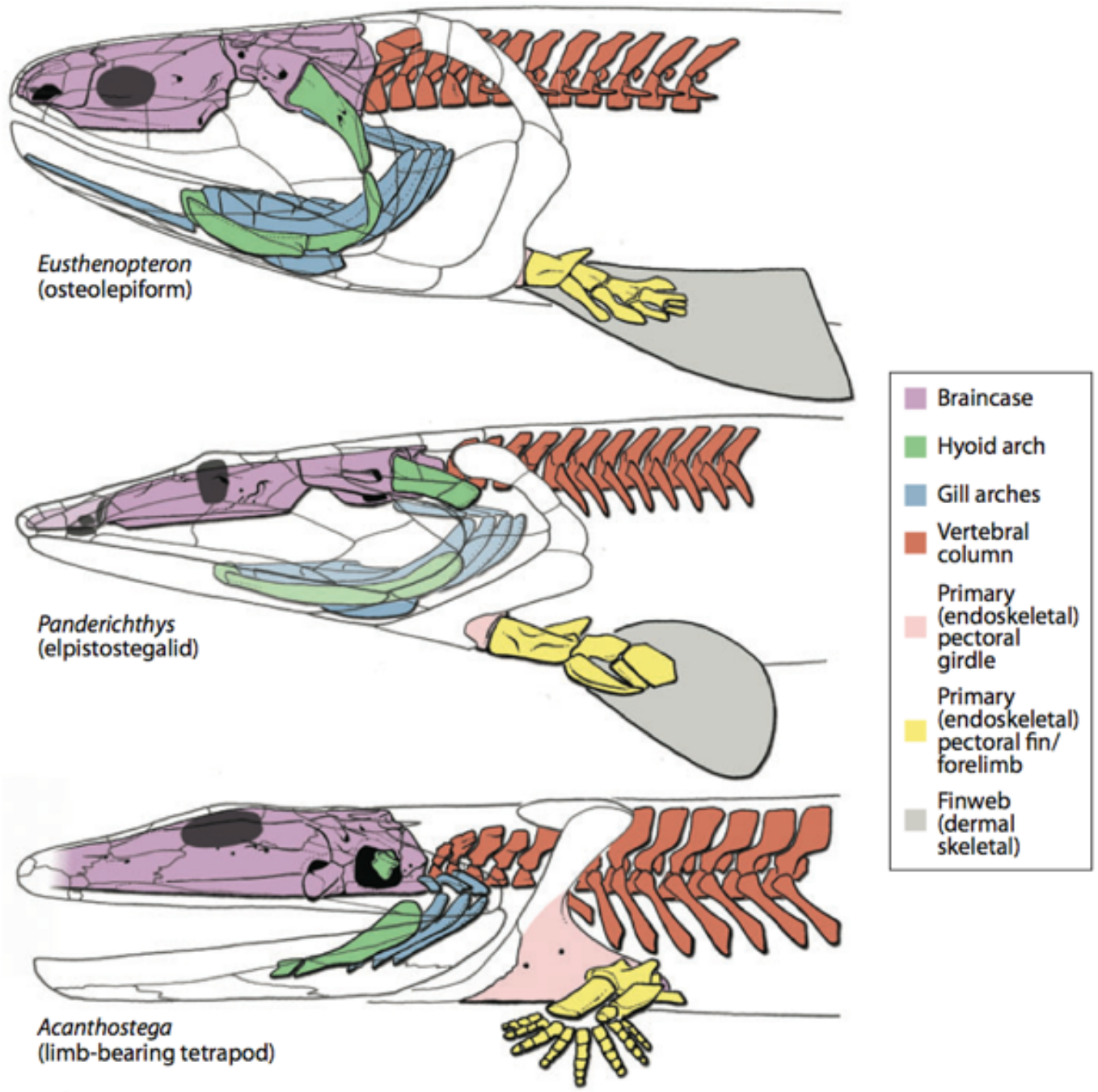
– 365 mya
– Best-known early tetrapod
– Limbs with 8 digits
– Aquatic

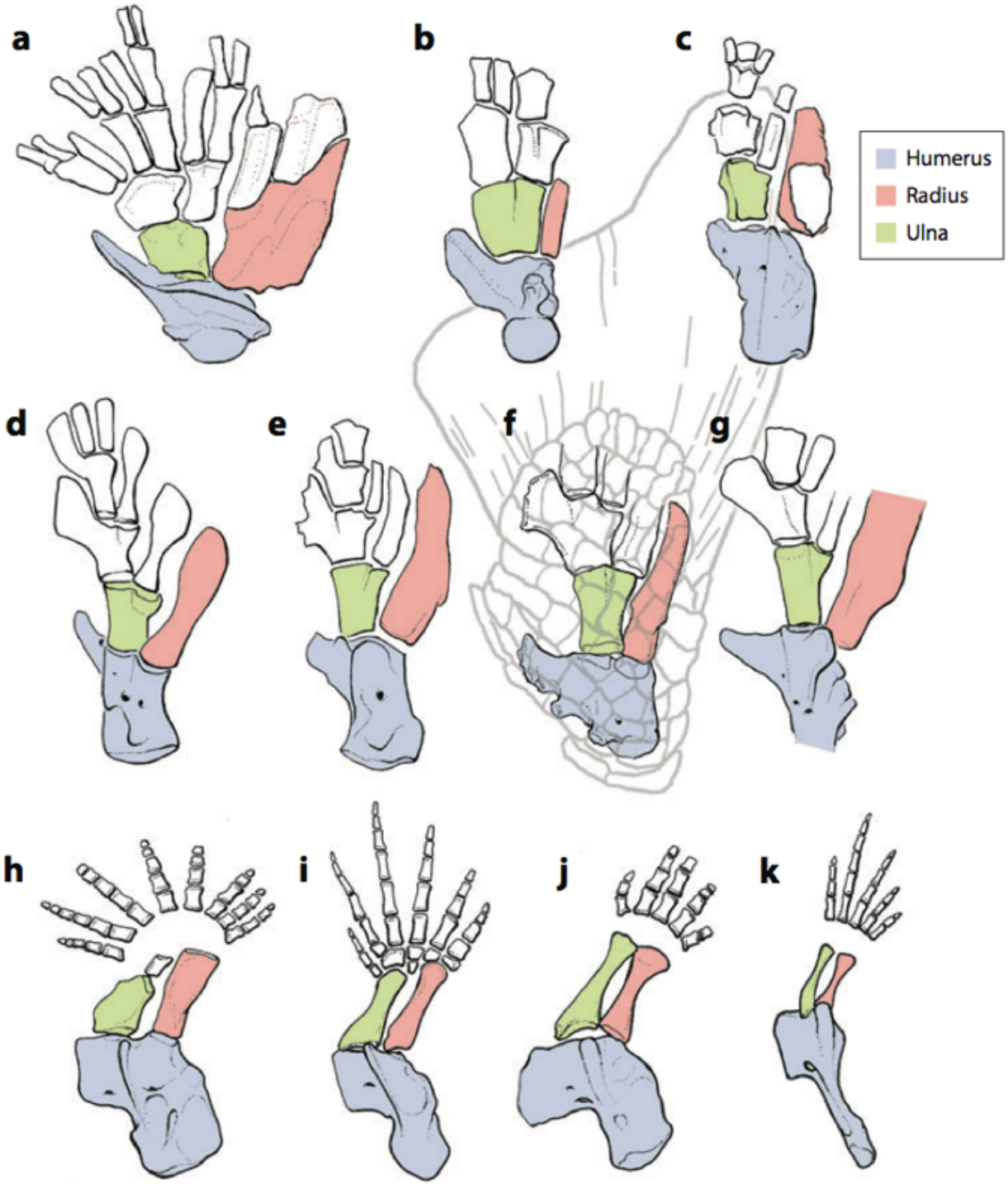

Acanthostega
Picture from *Science*
(Janice McCafferty)

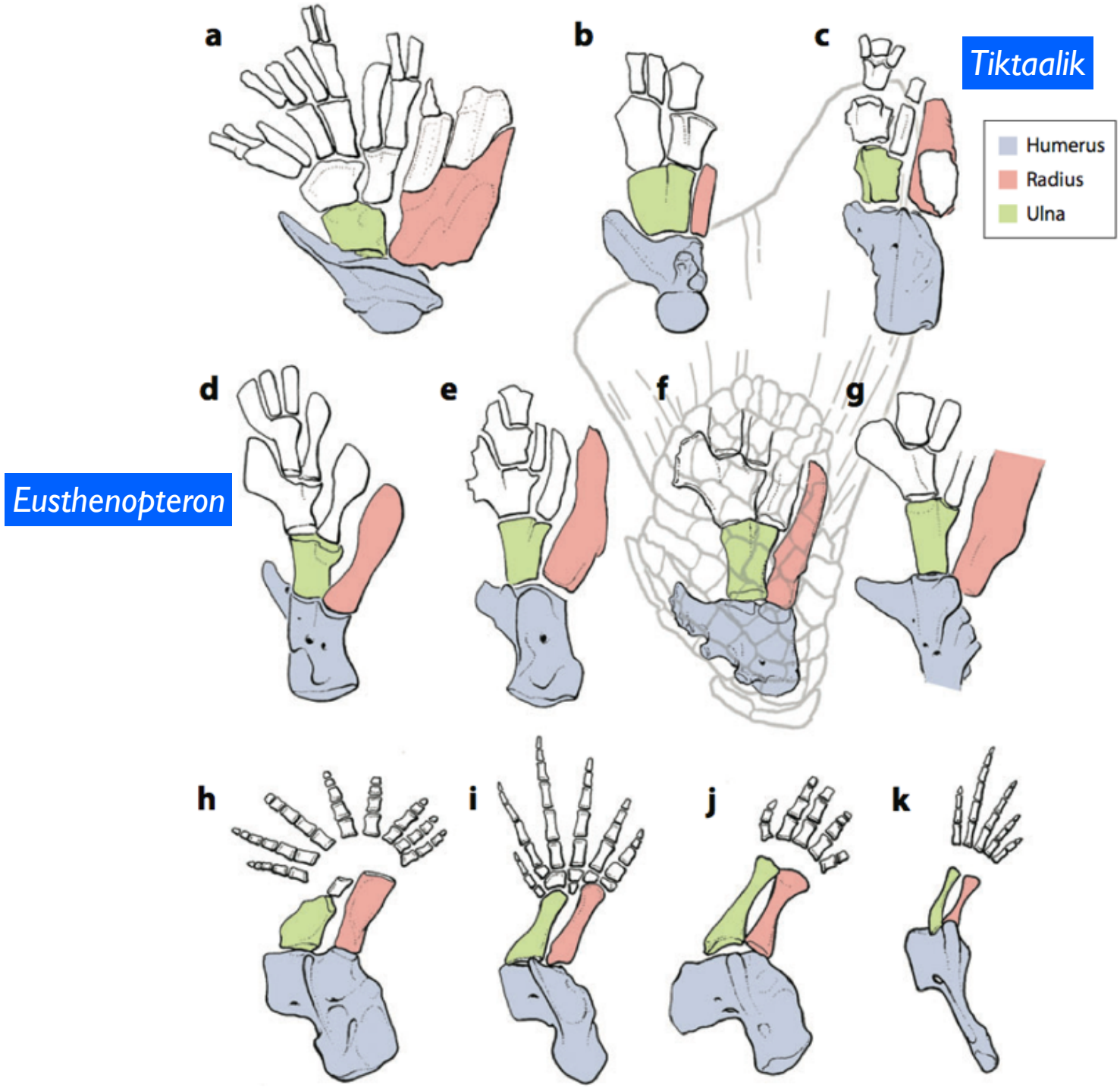
Ichthyostega

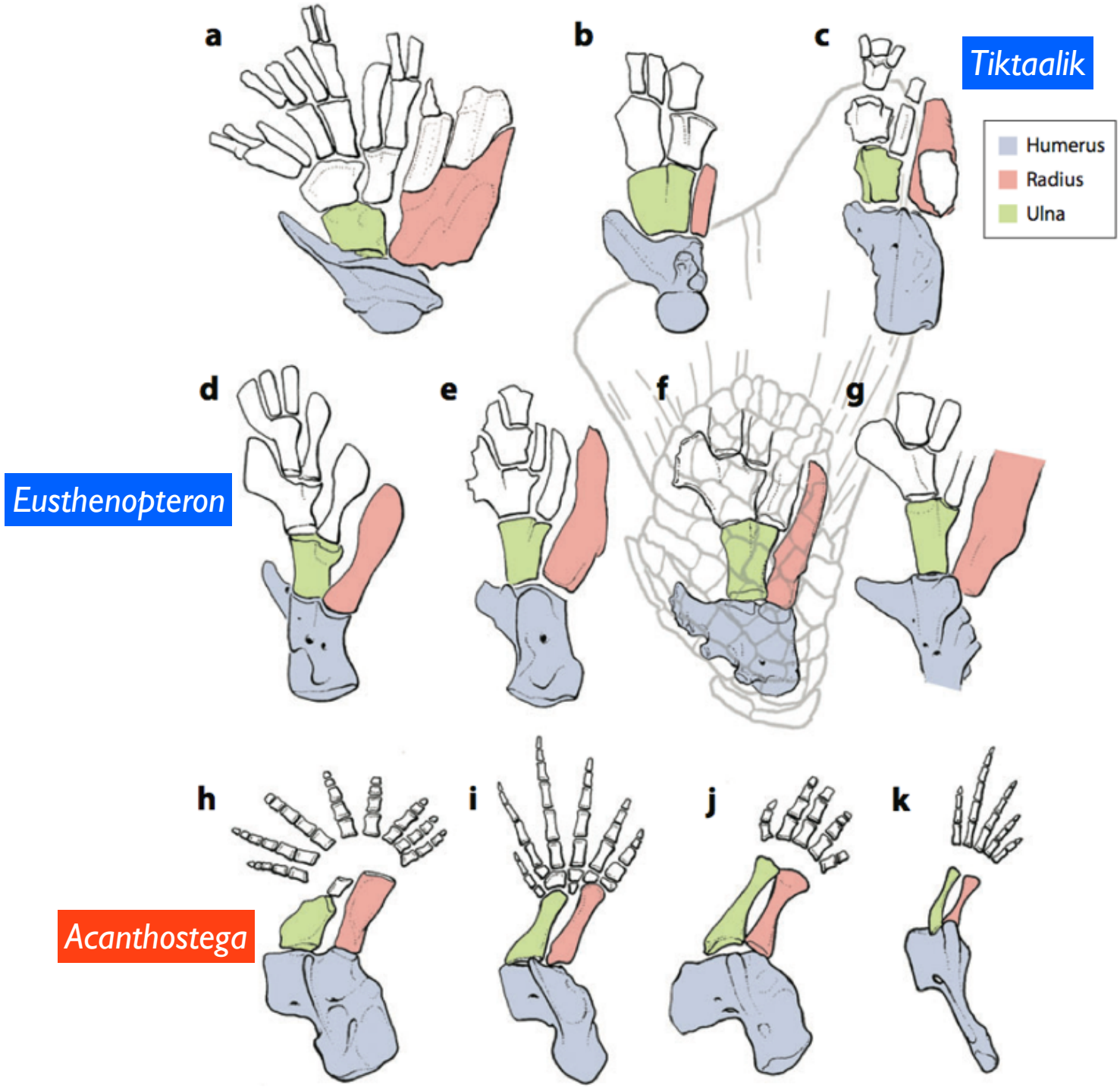
- 365 mya
- Limbs with 7 digits
- Fish-like tail but likely some ability to move on land

All of these organisms had limbs but were aquatic!


Eusthenopteron
(osteolepiform)
Panderichthys
(elpistostegalid)
Acanthostega
(limb-bearing tetrapod)
Braincase
Hyoid arch
Gill arches
Vertebral column
Primary (endoskeletal) pectoral girdle
Primary (endoskeletal) pectoral fin/ forelimb
Finweb (dermal skeletal)


a
b
c
d
e
f
g
h
i
j
k
Humerus
Radius
Ulna


Tiktaalik
Humerus
Radius
Ulna
Eusthenopteron
a
b
c
d
e
f
g
h
i
j
k


a
b
c
Tiktaalik
Humerus
Radius
Ulna
d
e
f
g
Eusthenopteron
h
i
j
k
Acanthostega

Things you might think about the transition to land

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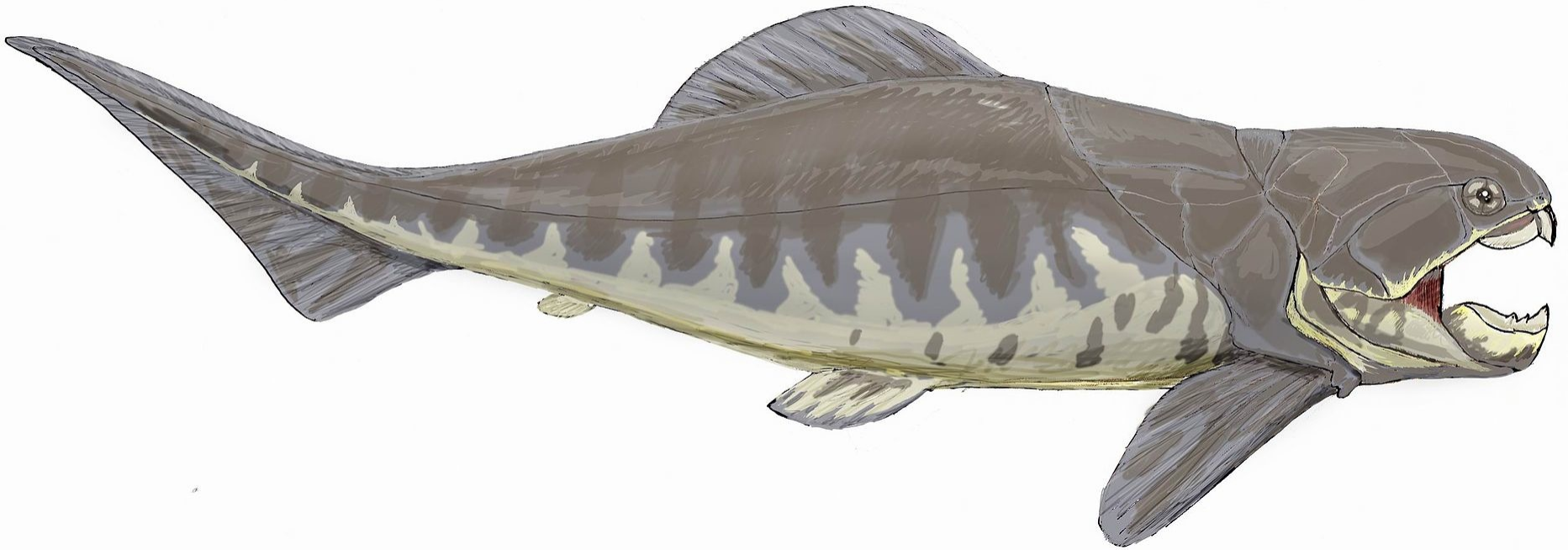


Dunkleosteus, a Devonian placoderm

Updated Story

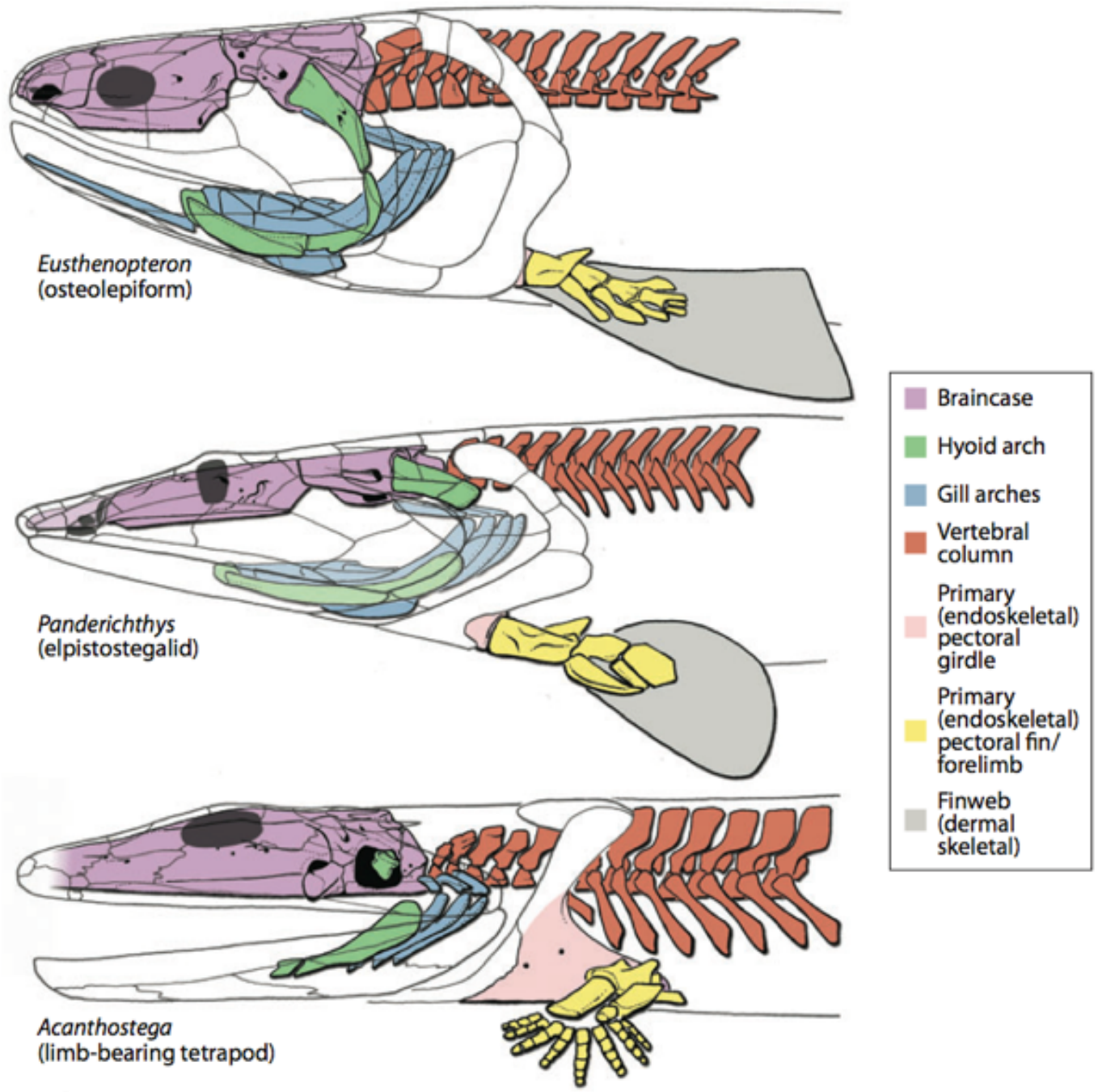
- Many features of tetrapods first evolved in an aquatic habitat
- These features turned out to be quite useful when the transition to land occurred
- **Exaptation**: a trait that evolved for one function that is co-opted by selection to serve another function

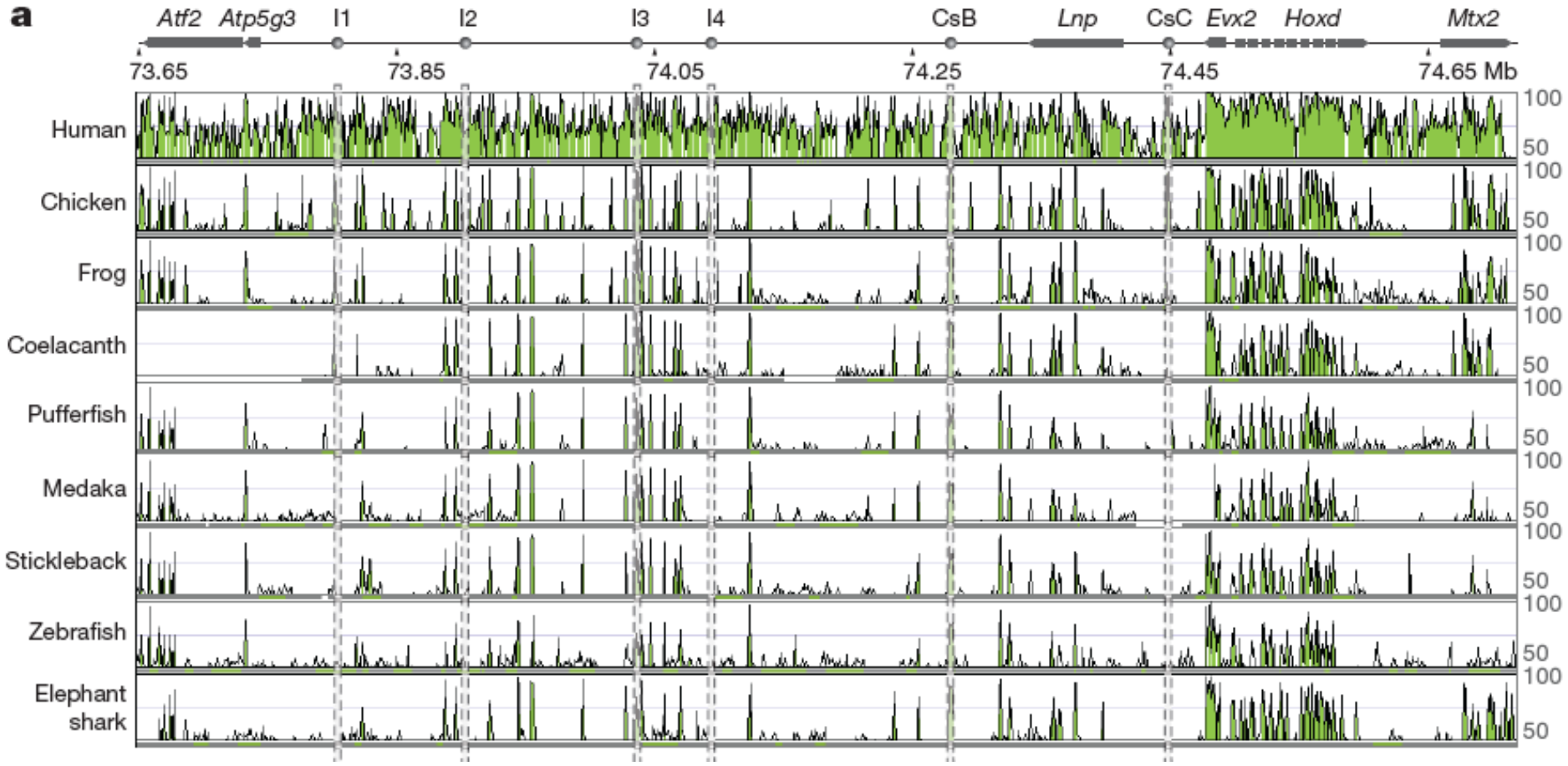
Ancestry matters!

https://www.youtube.com/watch?v=rYOf2wIoxgo

How do we learn about the origin of herps?

- Study relationships among living species
- Find and analyze fossils
- Understand genetics and development


Eusthenopteron
(osteolepiform)
Panderichthys
(elpistostegalid)
Acanthostega
(limb-bearing tetrapod)
Braincase
Hyoid arch
Gill arches
Vertebral column
Primary (endoskeletal) pectoral girdle
Primary (endoskeletal) pectoral fin/ forelimb
Finweb (dermal skeletal)


a
Atf2
Atp5g3
I1
I2
I3
I4
CsB
Lnp
CsC
Evx2
Hoxd
Mtx2
73.65
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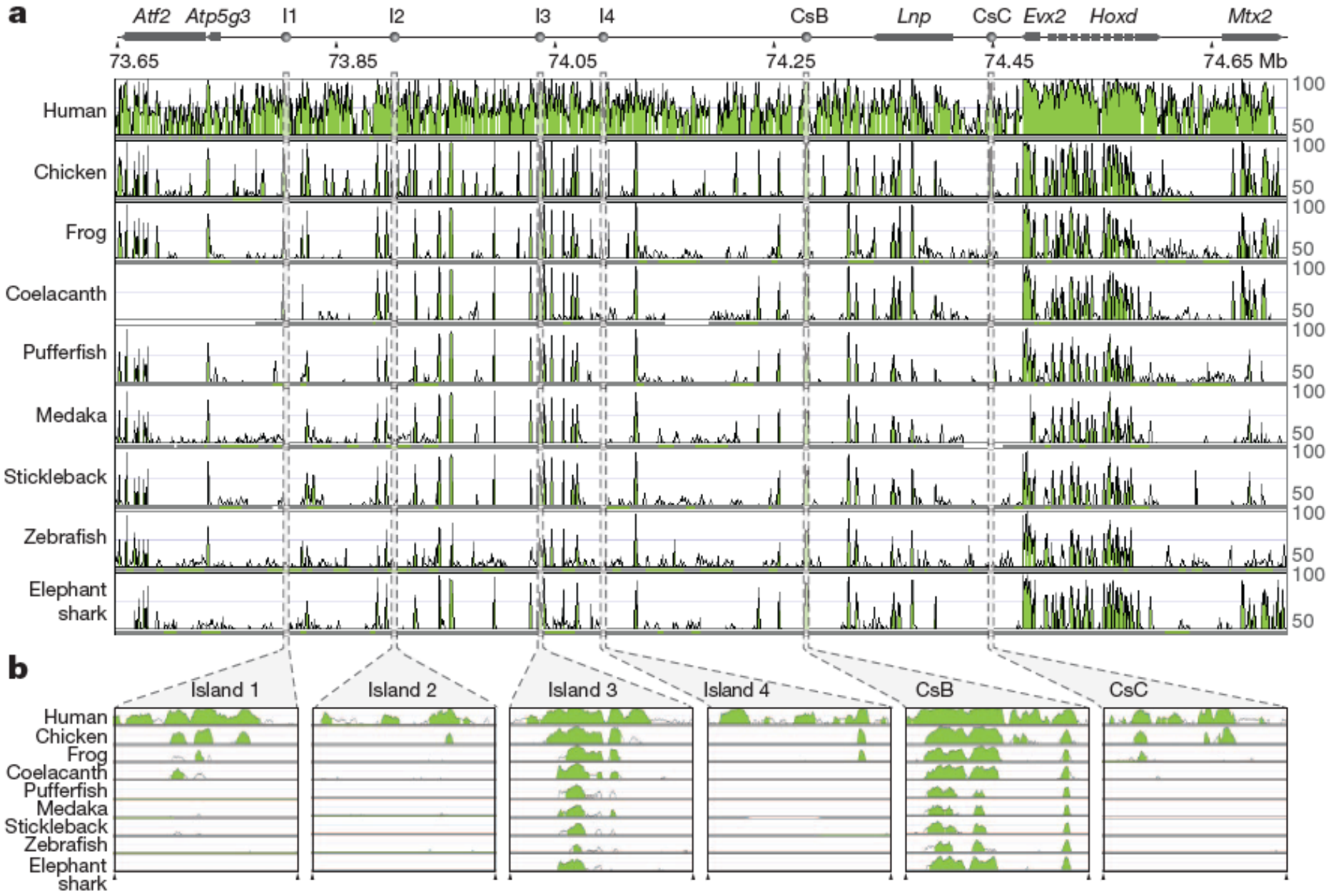
74.05
74.25
74.45
74.65 Mb
Human
Chicken
Frog
Coelacanth
Pufferfish
Medaka
Stickleback
Zebrafish
Elephant shark
100
50


a
Atf2
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Human
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Medaka
Stickleback
Zebrafish
Elephant shark
100
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b
Island 1
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Frog
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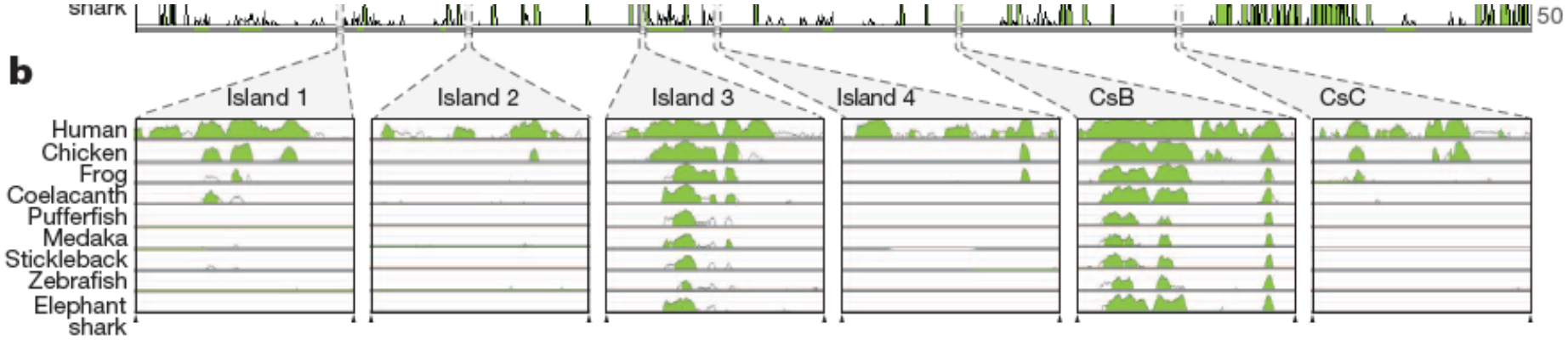
Pufferfish
Medaka
Stickleback
Zebrafish
Elephant shark


shark
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Island 2
Island 3
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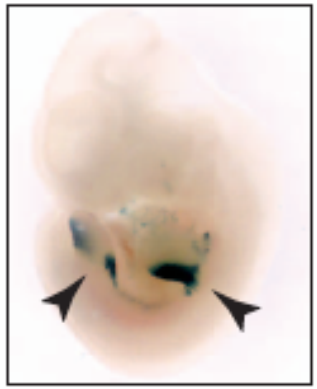
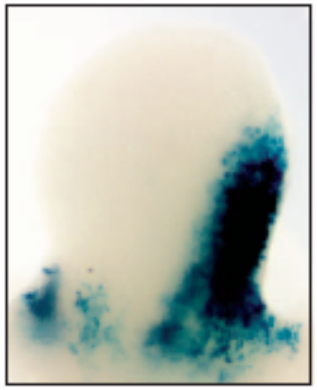
CsC
Human
Chicken
Frog
Coelacanth
Pufferfish
Medaka
Stickleback
Zebrafish
Elephant shark

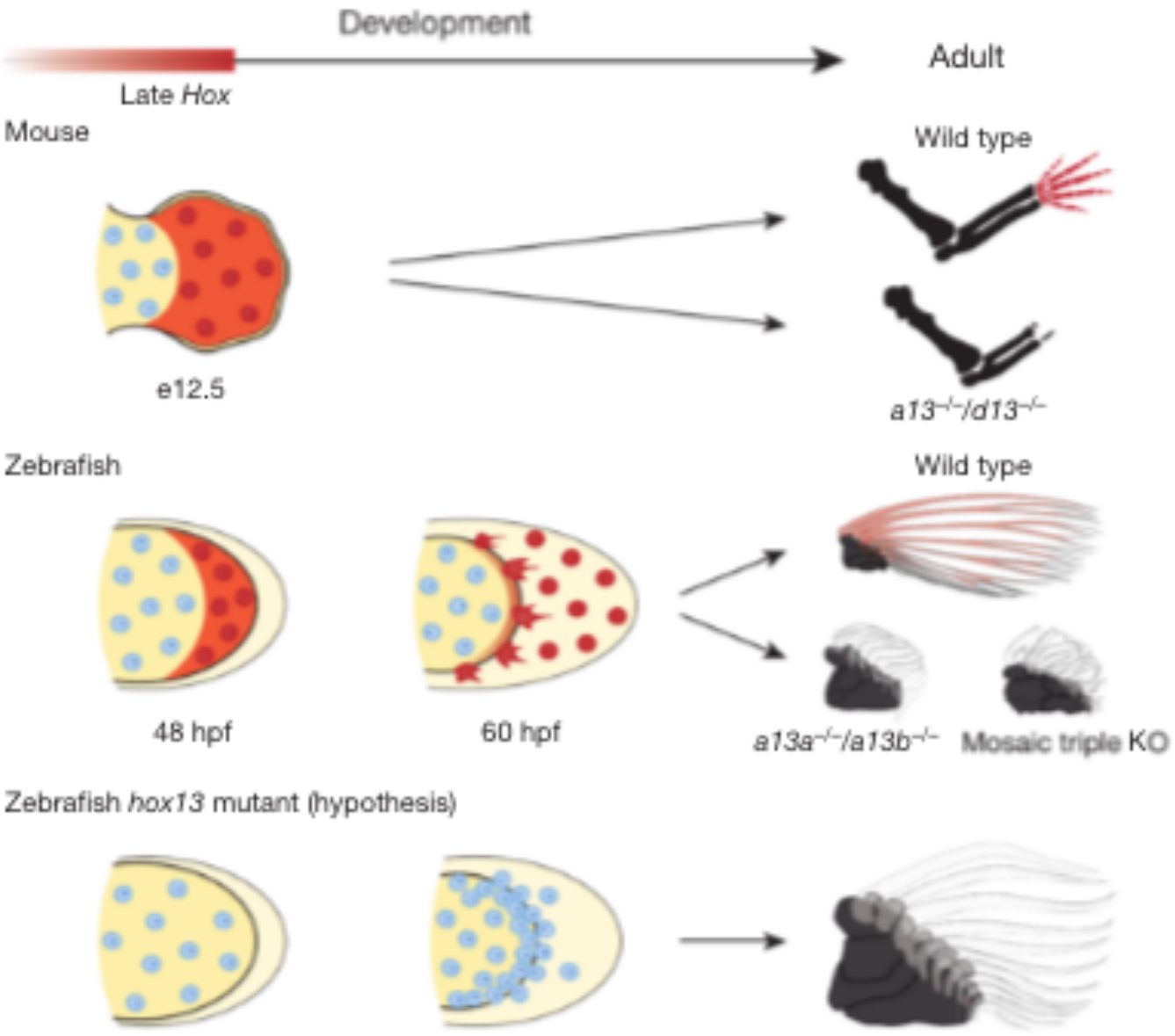
c





Coelocanth and tetrapods share a HOX-D regulatory element that is associated with limb-bud development

This HOX-D element is very likely a key genetic change associated with the early origins of tetrapods

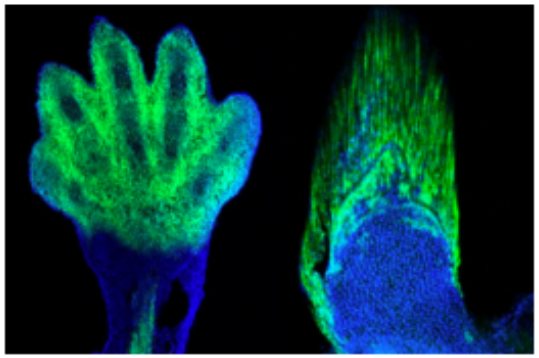

Development
Adult
Late Hox
Mouse
Wild type
e12.5
a13−/−/d13−/−
Zebrafish
Wild type
48 hpf
60 hpf
a13a−/−/a13b−/−
Mosaic triple KO
Zebrafish hox13 mutant (hypothesis)

The New York Times

Science

CRAIG COOK/UNDERSEA MEDICAL

Giant Coral Reef in Protected Area Shows New Signs of Life



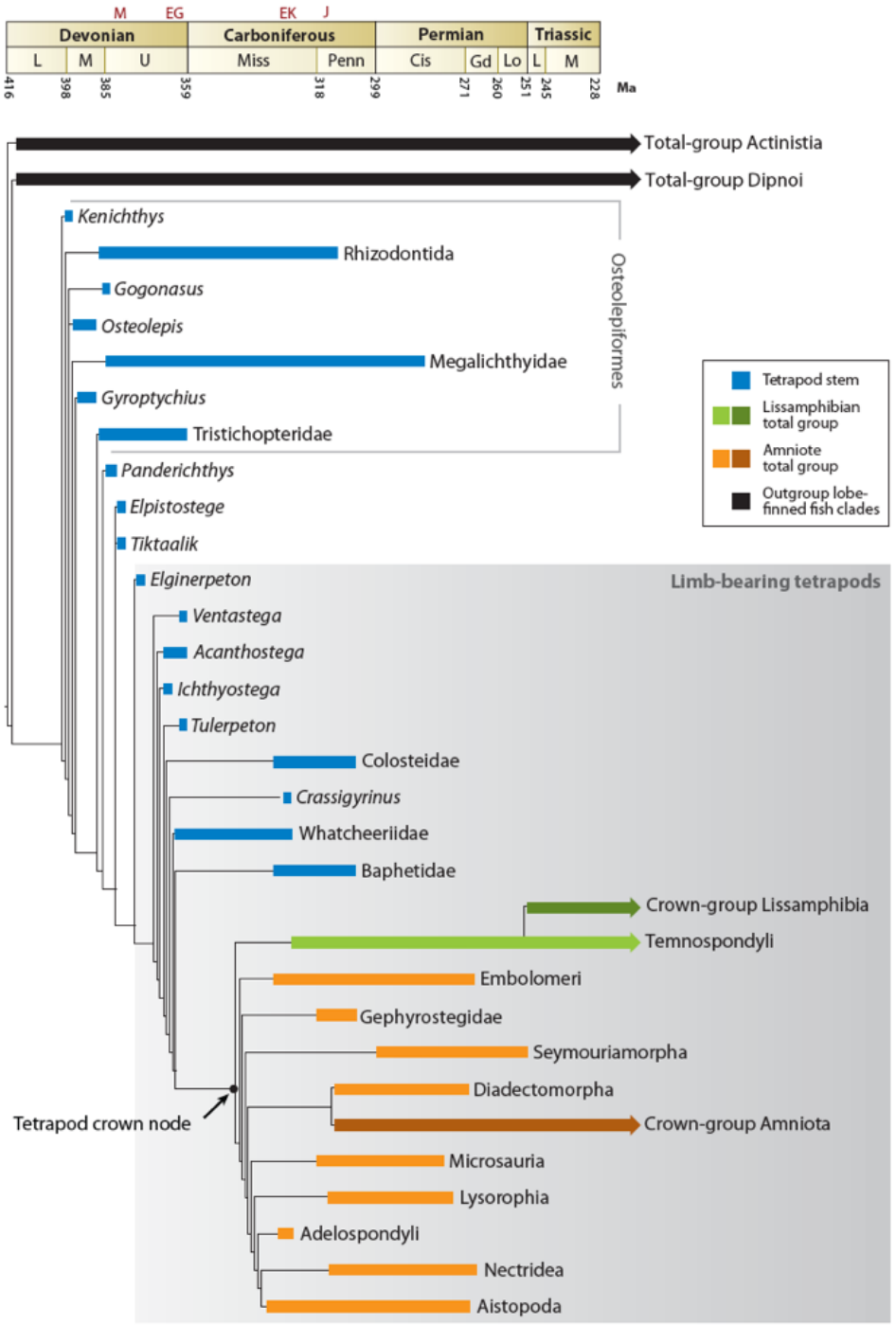
MARIE KMITA AND ANDREW GEHRKE

MATTER

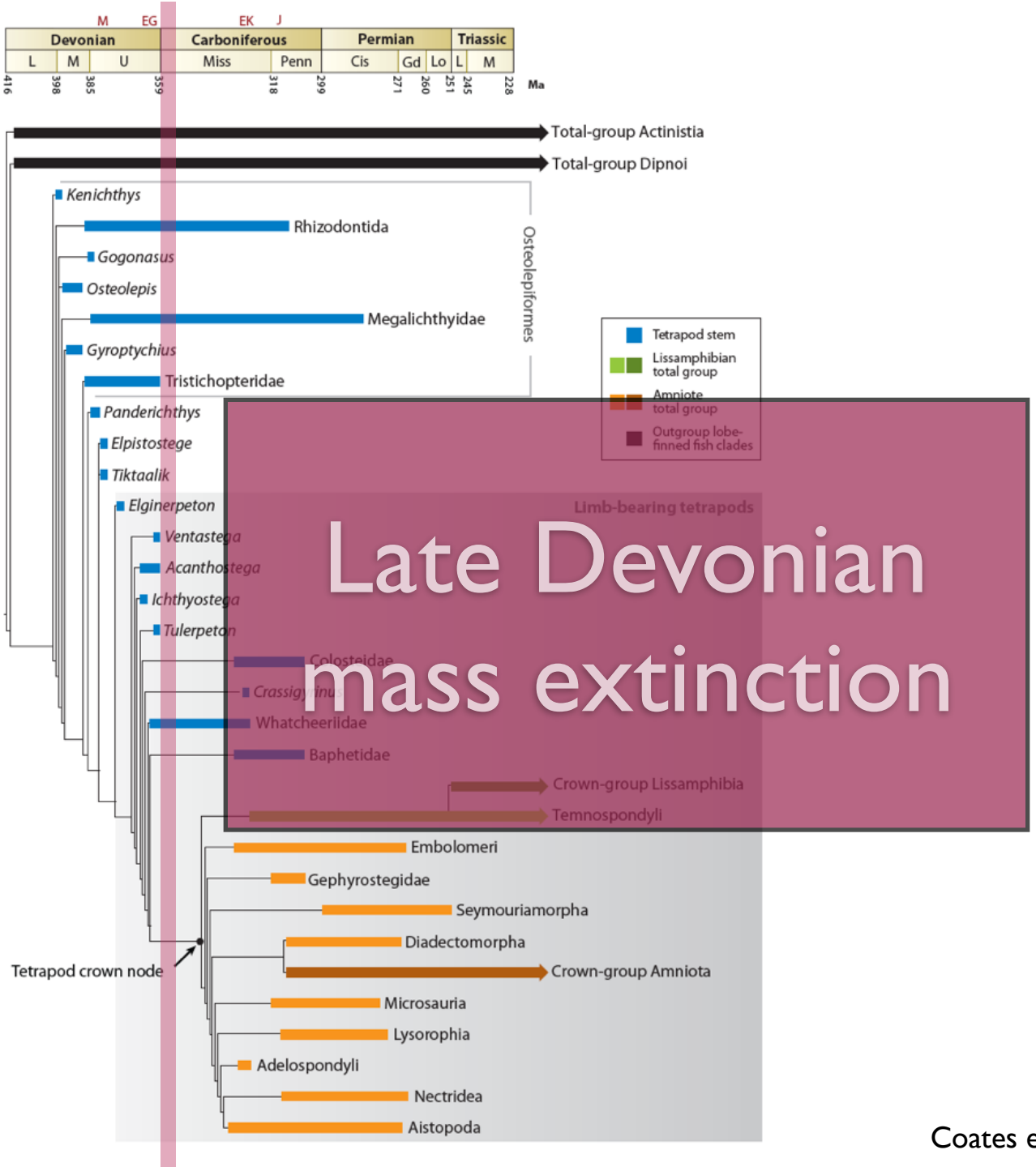
From Fins Into Hands: Scientists Discover a Deep Evolutionary Link

The findings by a University of Chicago team will help researchers understand how our ancestors left the water, transforming fins into limbs so they could move on land.

1d ago · By CARL ZIMMER



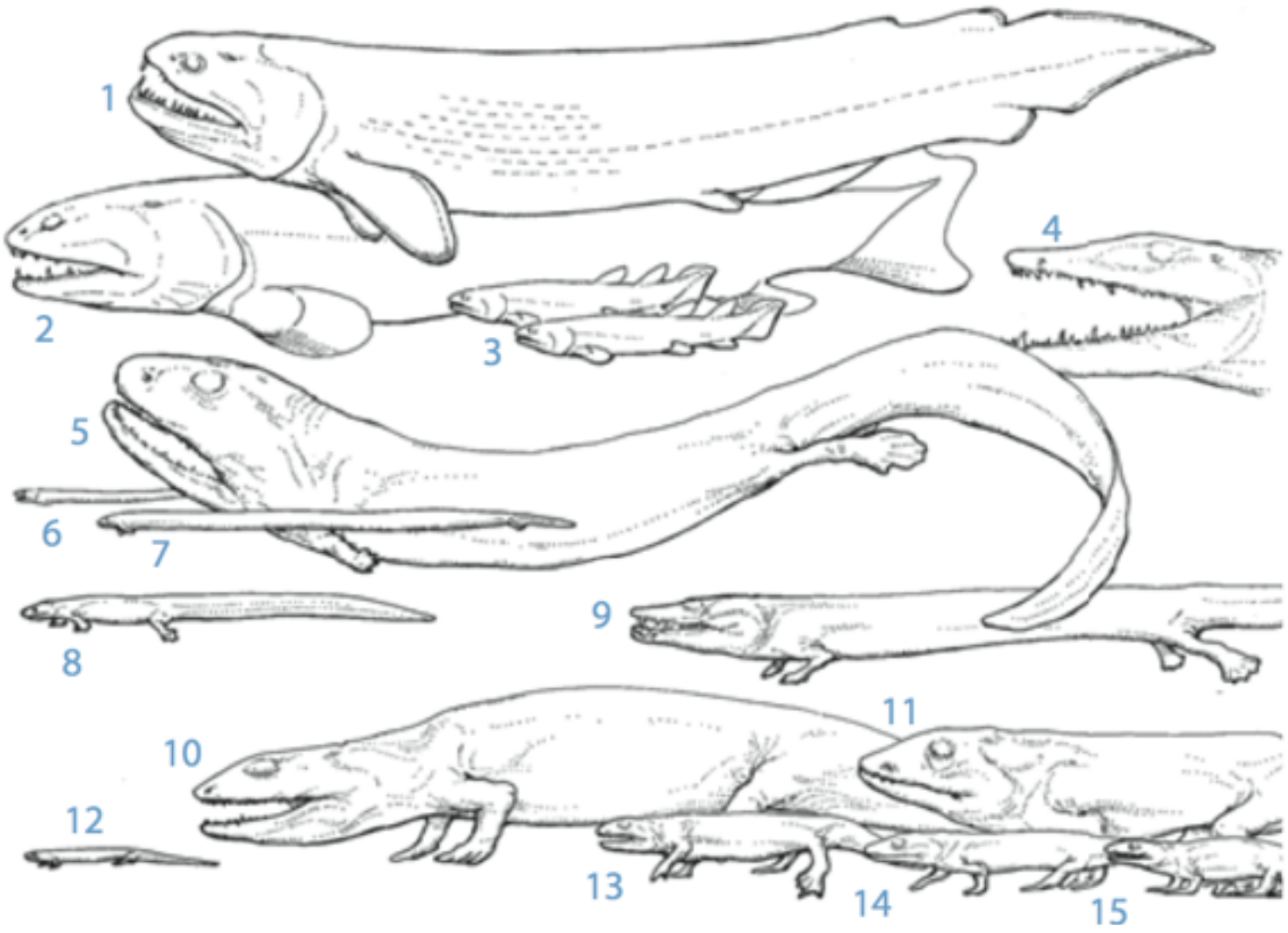
Coates et al. 2008



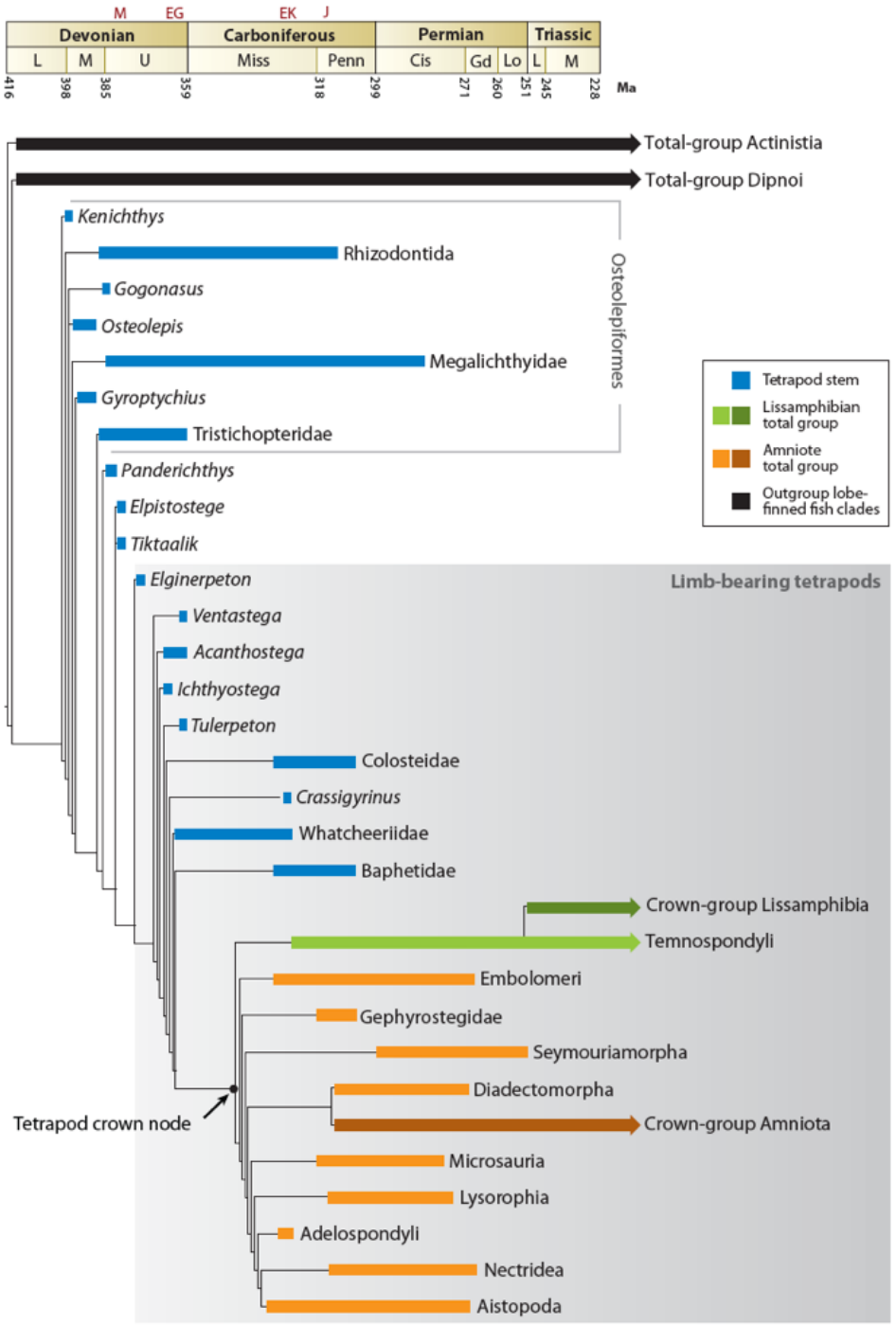
Late Devonian mass extinction

Coates et al. 2008

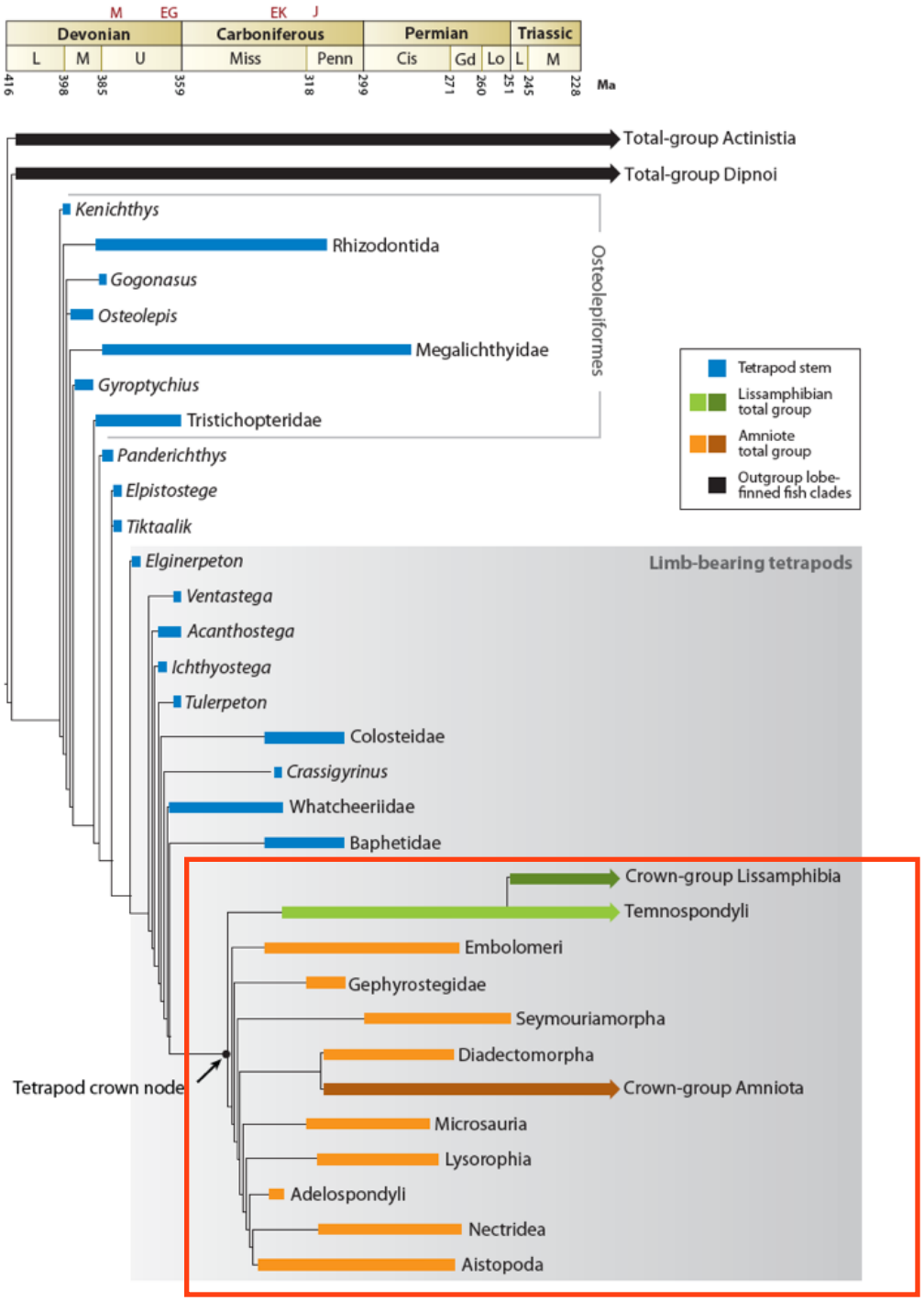
Carboniferous tetrapods



Crassigyrinus will haunt your nightmares



Coates et al. 2008



Coates et al. 2008

Crown-group tetrapods illustrate the rapid divergence of today's major tetrapod groups:

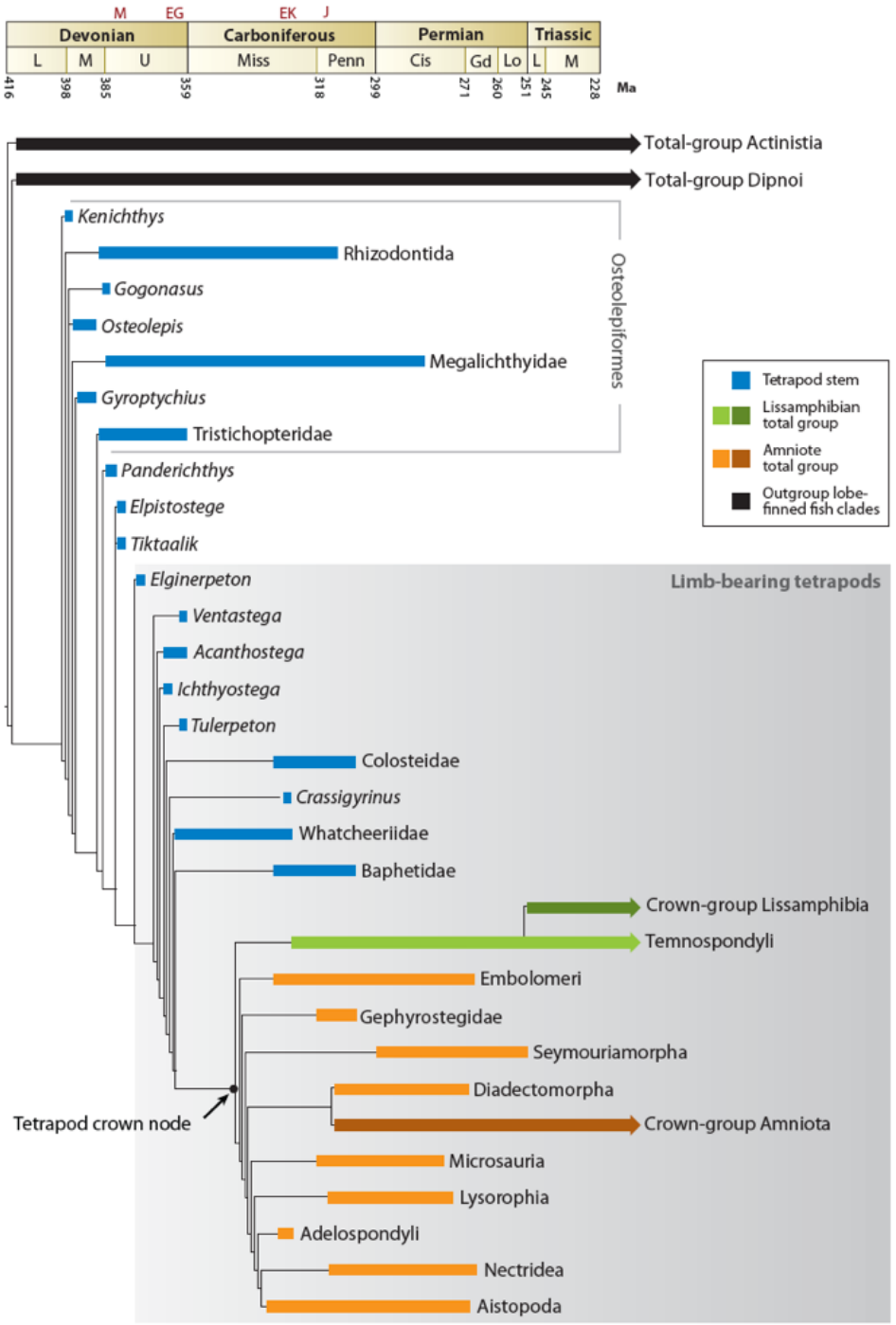
Crown-group tetrapods illustrate the rapid divergence of today's major tetrapod groups:

amphibians, reptiles (including birds), and mammals

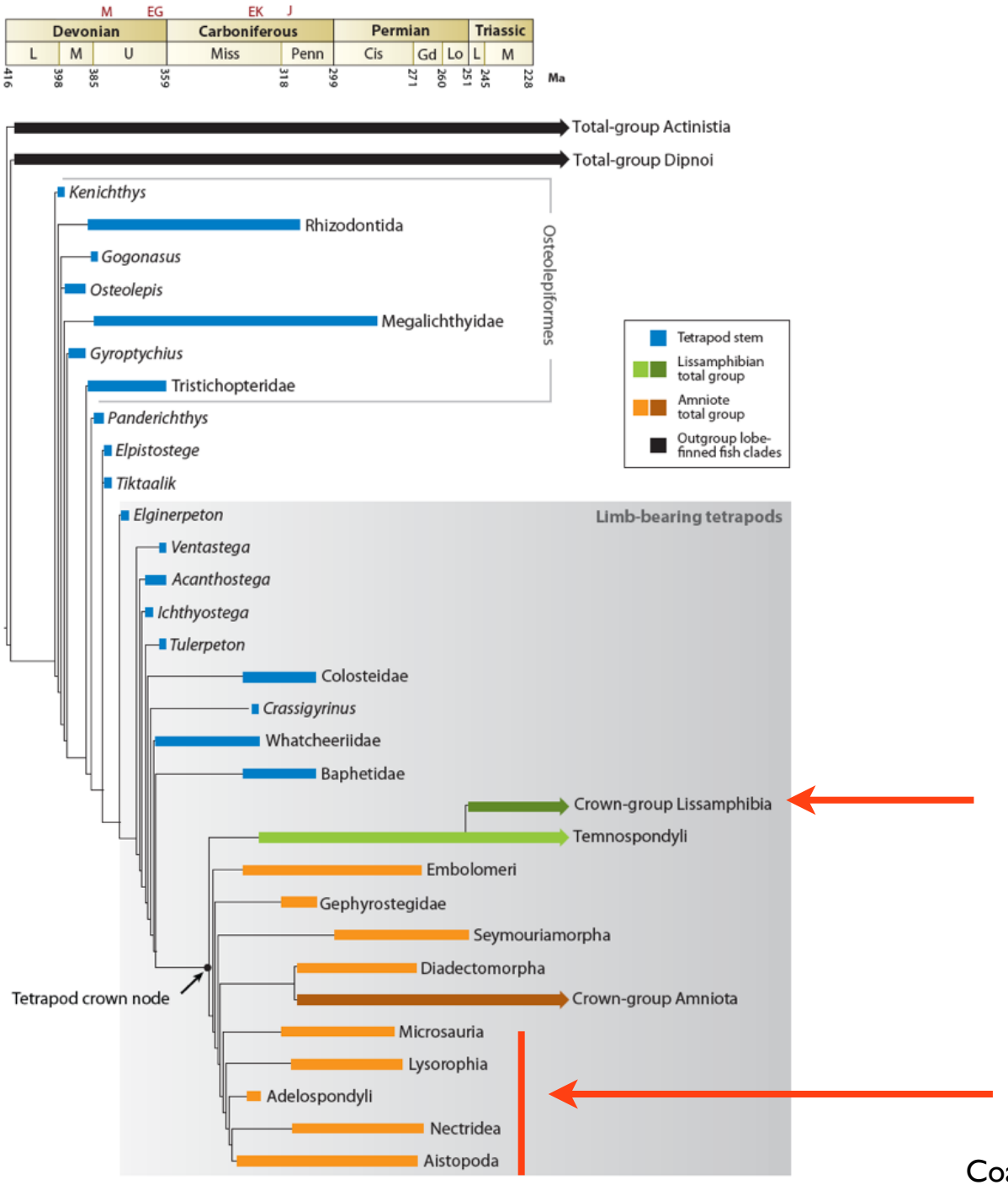
Crown-group tetrapods illustrate the rapid divergence of today's major tetrapod groups:

amphibians, reptiles (including birds), and mammals

but there is also a diversity of tetrapod clades from the Carboniferous that left no modern descendants



Coates et al. 2008



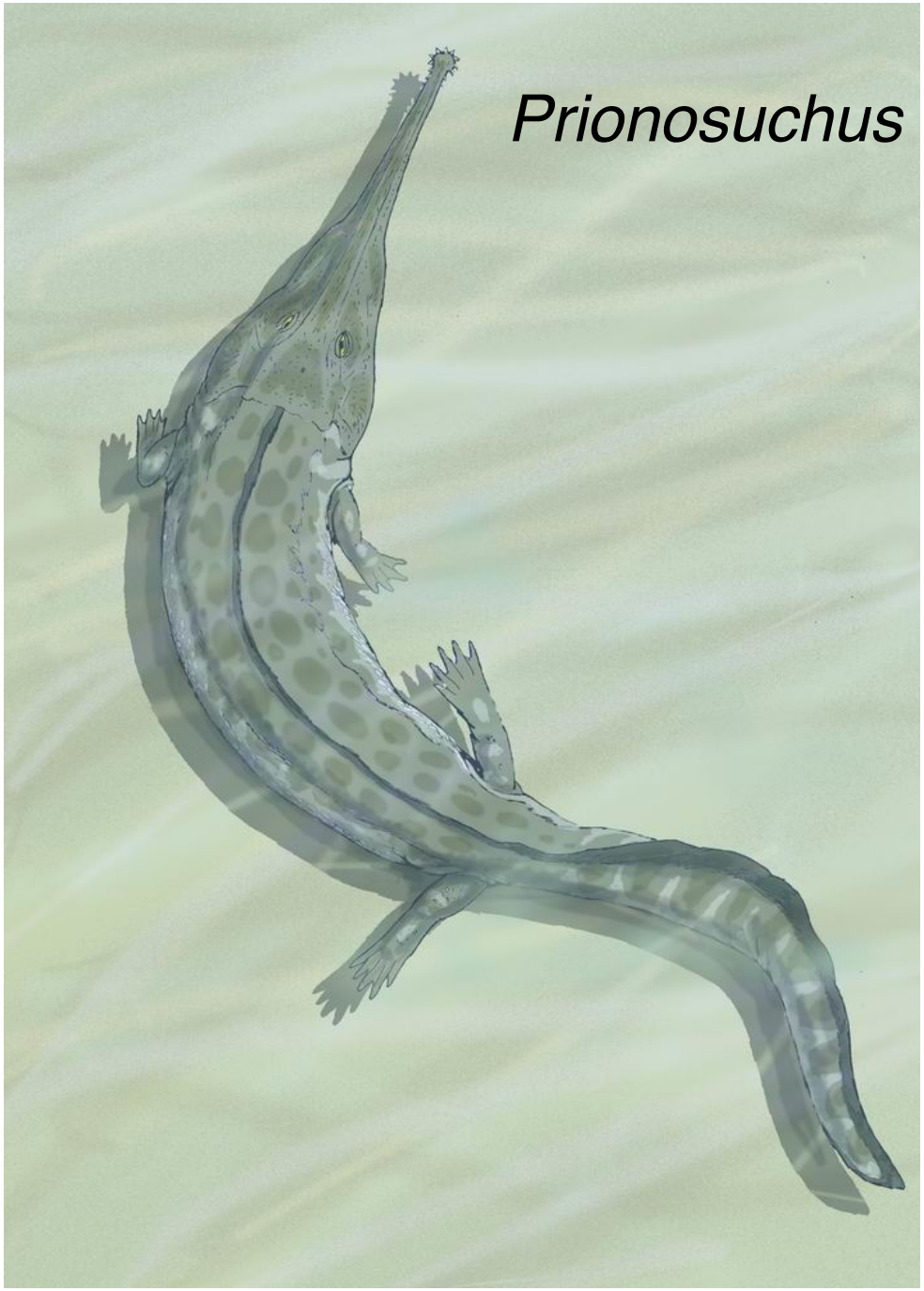
Coates et al. 2008

Origin of Lissamphibia

- Their extinct relatives are extremely contentious
- Probably came from one of two groups: Temnospondyls or Lepospondyls
- This is a major unsolved problem in herpetology

Temnospondyls

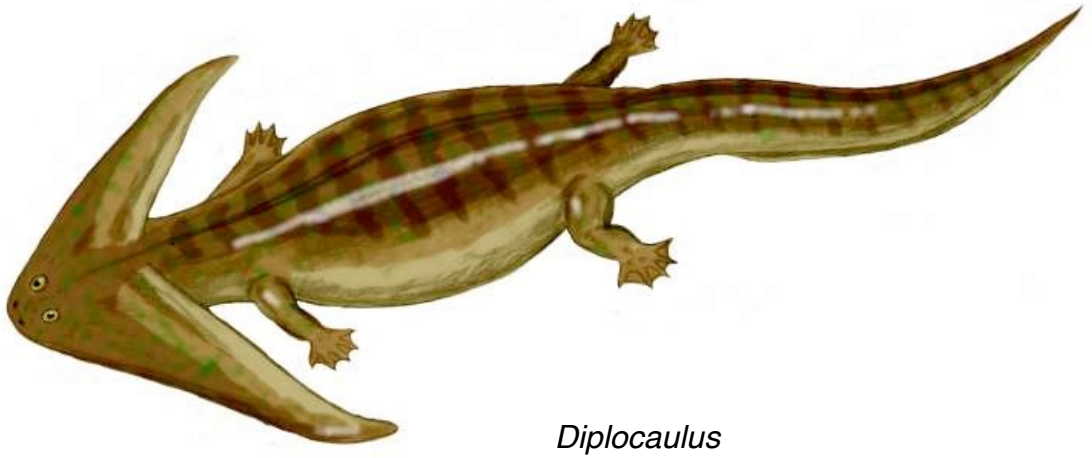
Capetus



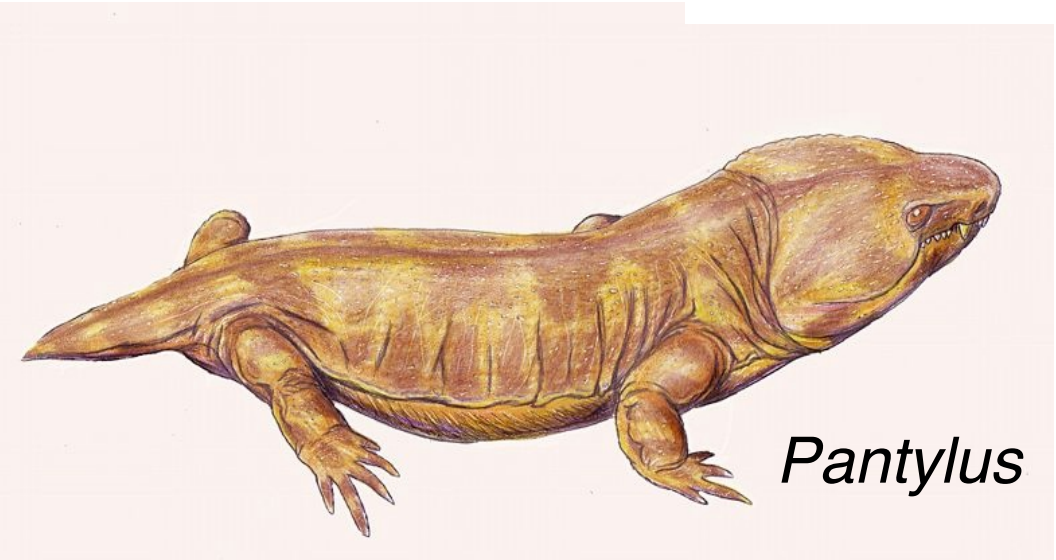
Temnospondyls

~270 mya
9 m long -
largest amphibian

Lepospondyls



Diplocaulus



Pantylus

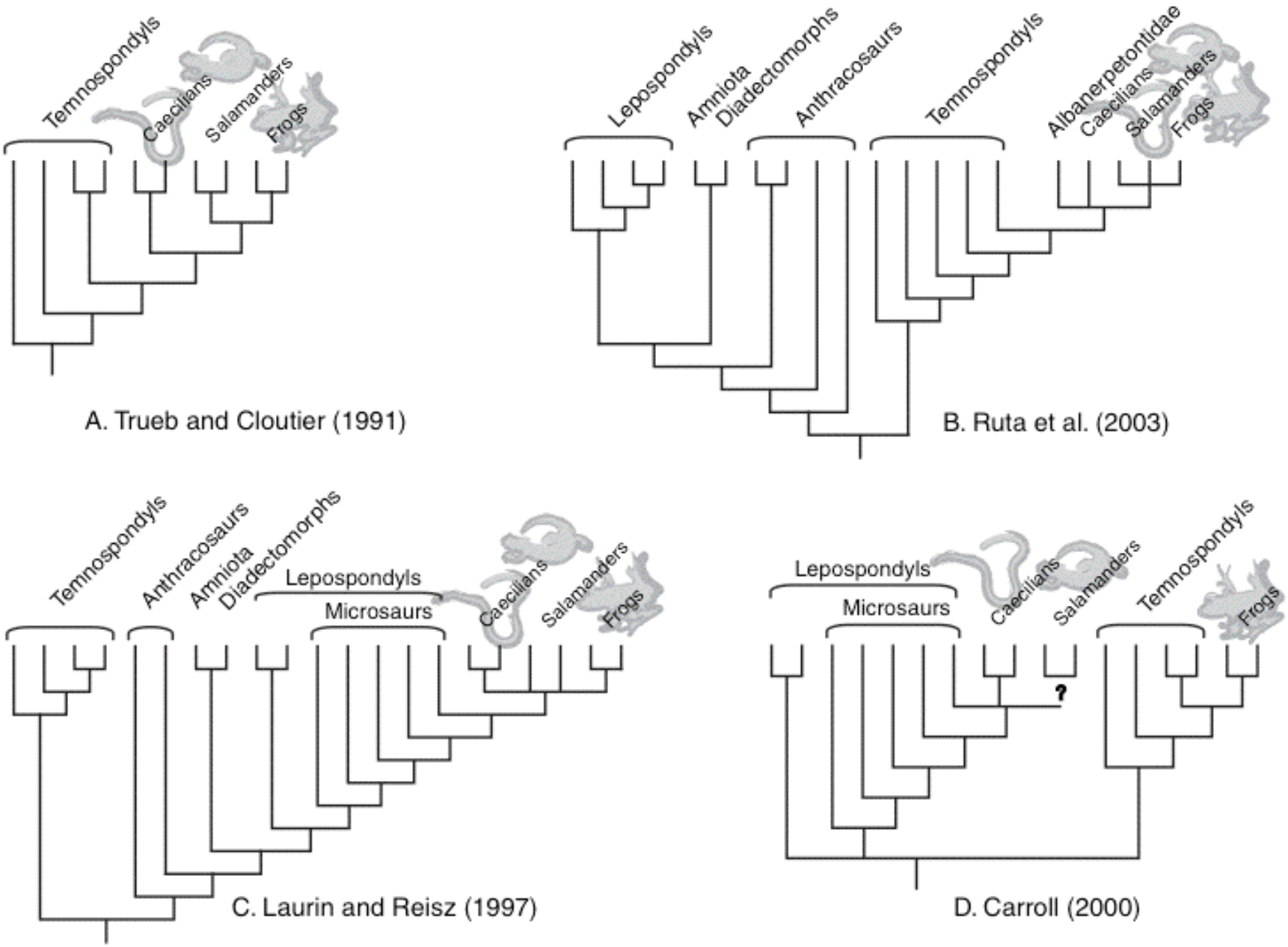
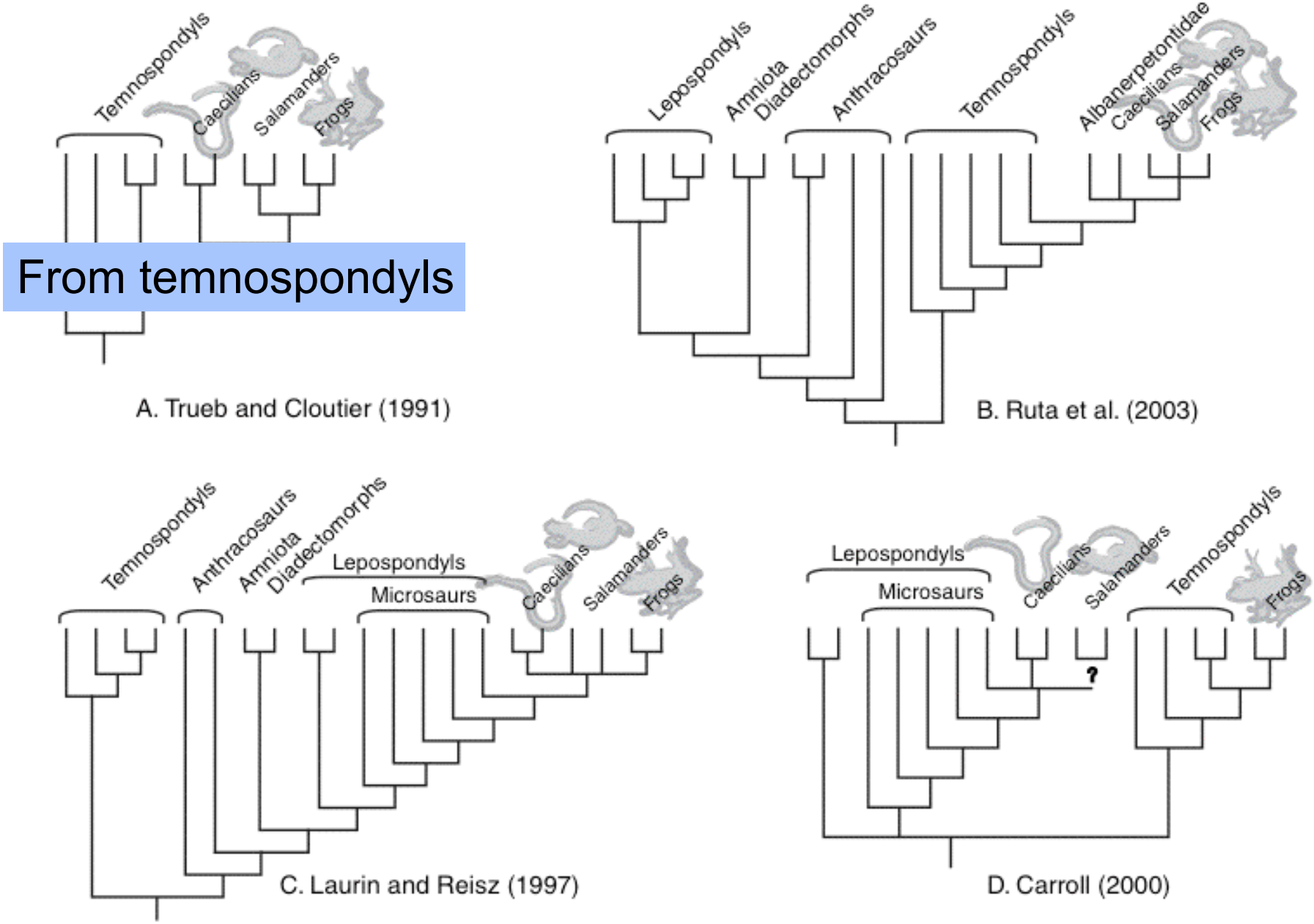


Figure 25.2. (A–D) Alternative relationships among modern amphibians (caecilians, frogs, and salamanders) and Paleozoic groups (temnospondyls, microsaurs, and lepospondyls).



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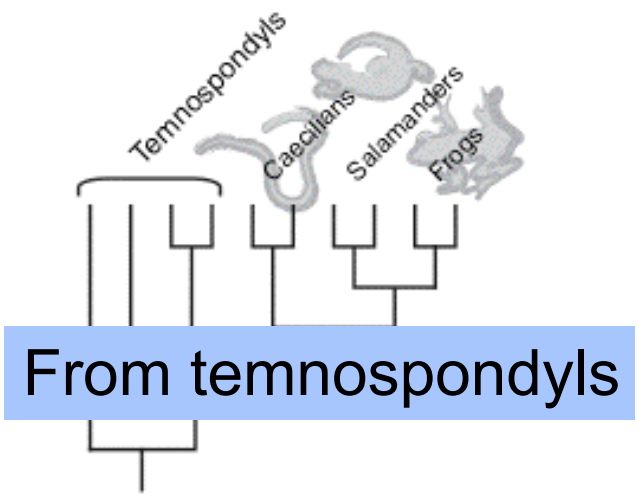
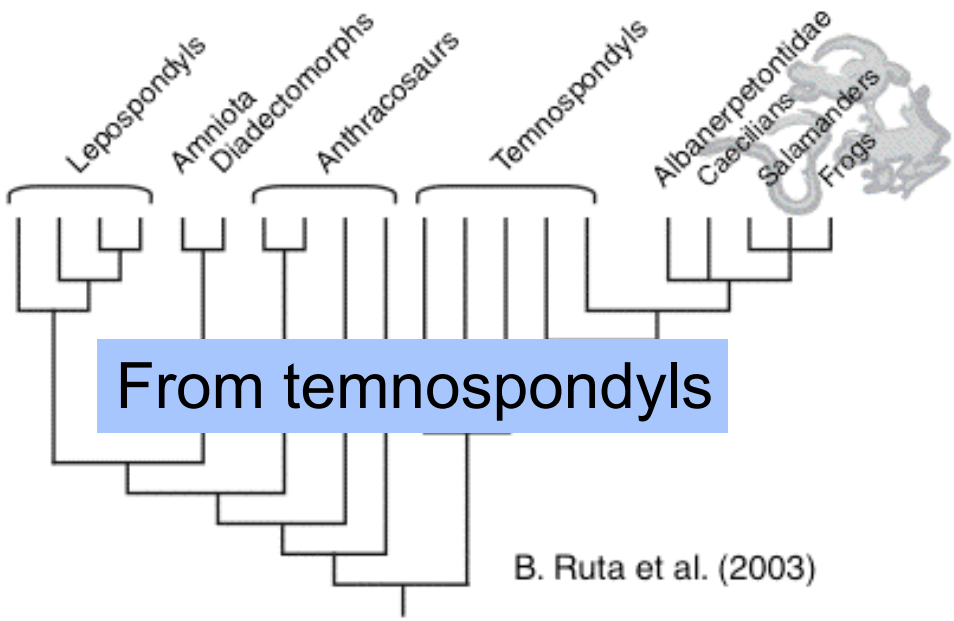


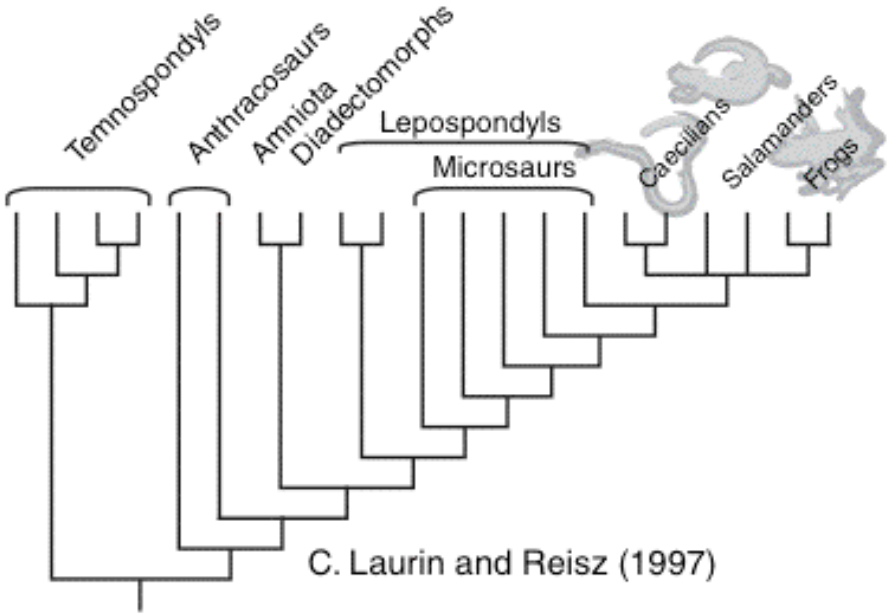
From temnospondyls

A. Trueb and Cloutier (1991)

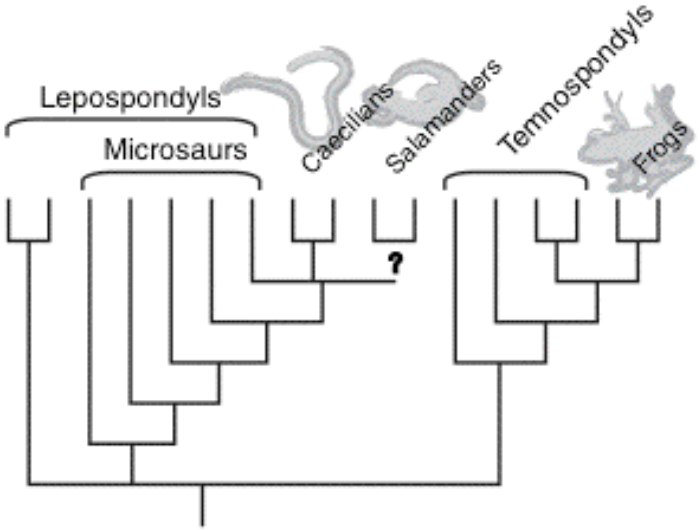


From temnospondyls

B. Ruta et al. (2003)



C. Laurin and Reisz (1997)



D. Carroll (2000)

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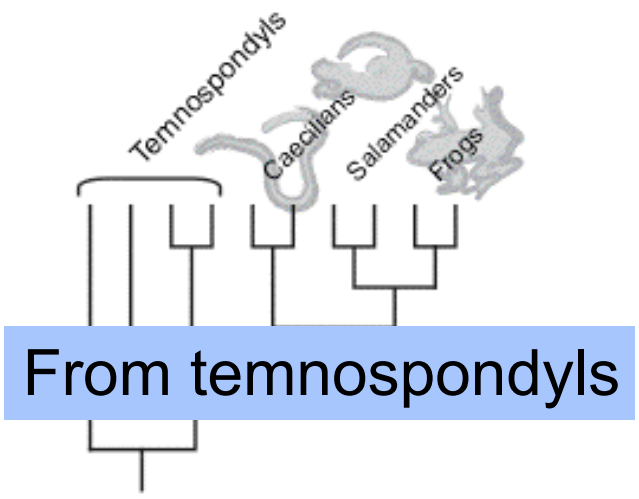

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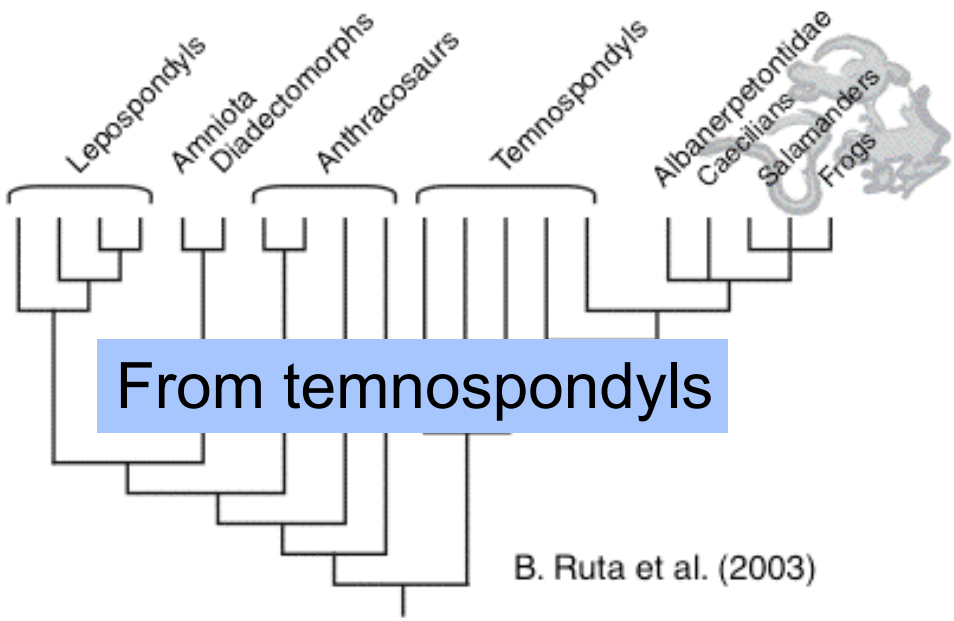

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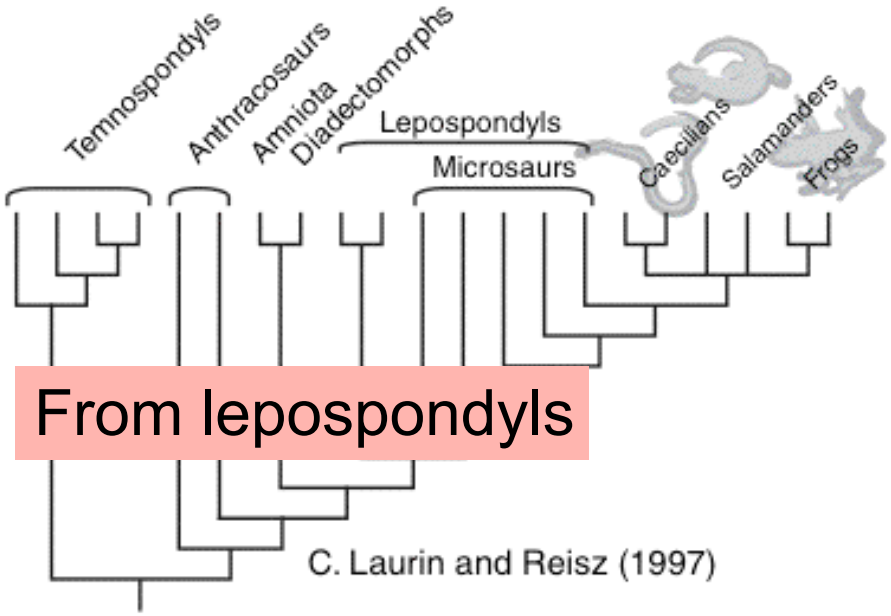
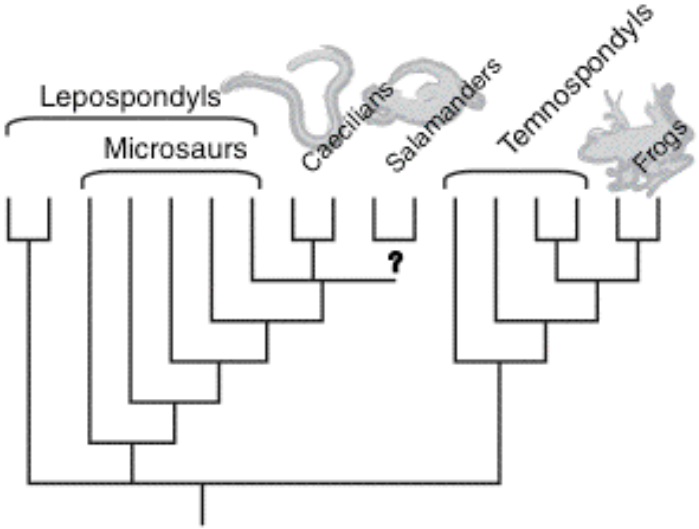


From lepospondyls

C. Laurin and Reisz (1997)



D. Carroll (2000)

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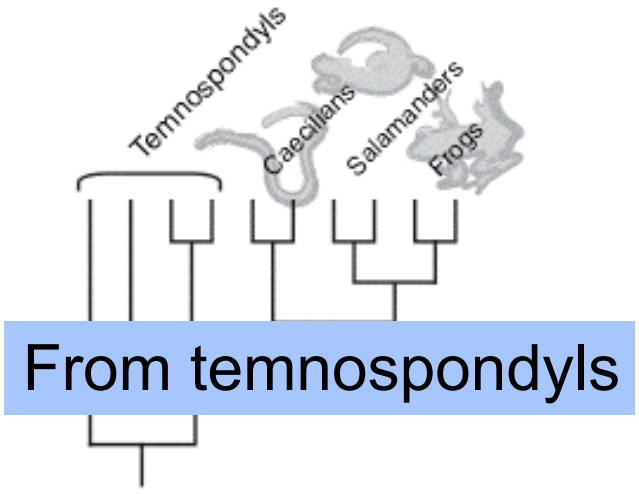

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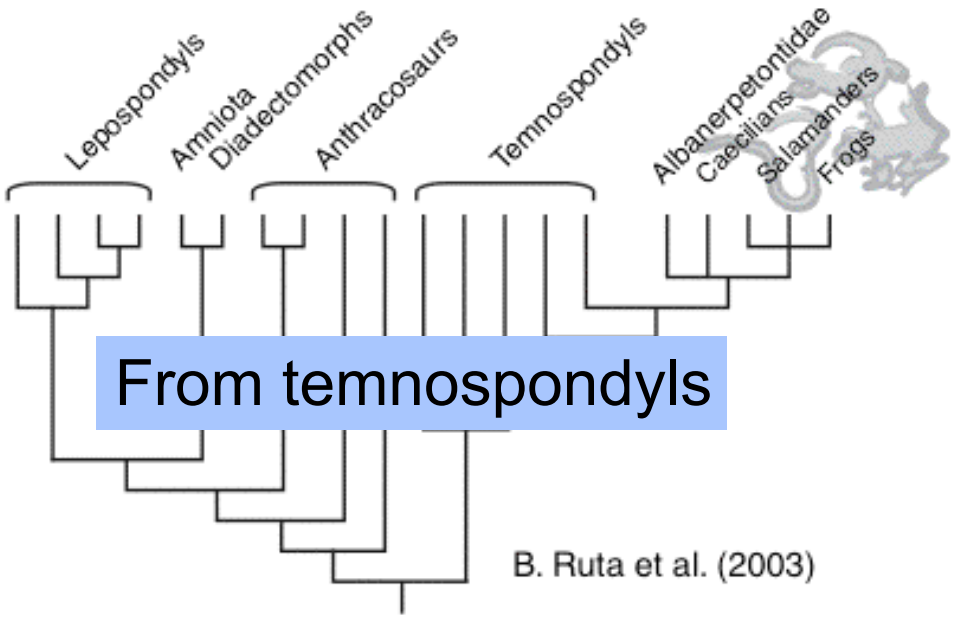

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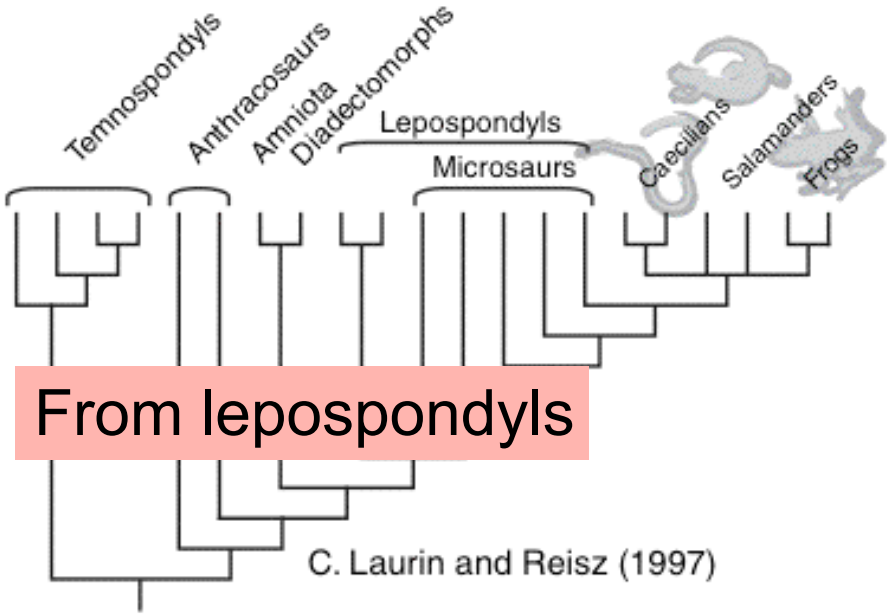

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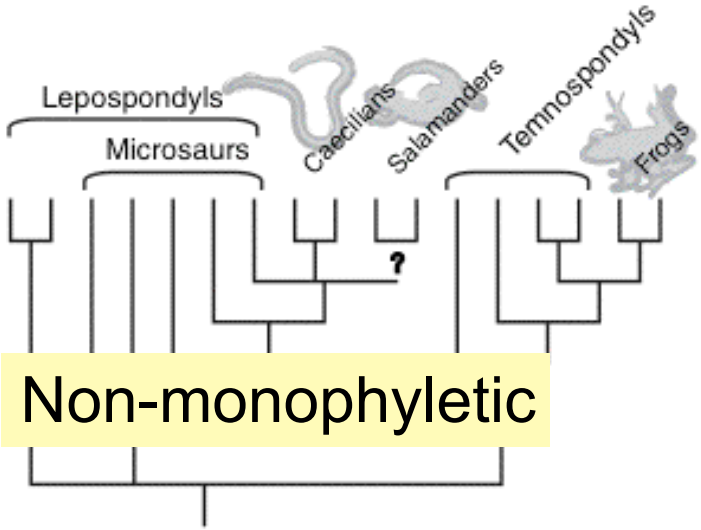

Non-monophyletic

D. Carroll (2000)

Figure 25.2. (A–D) Alternative relationships among modern amphibians (caecilians, frogs, and salamanders) and Paleozoic groups (temnospondyls, microsaurs, and lepospondyls).

Vol 453|22 May 2008|doi:10.1038/nature06865 nature

LETTERS

A stem batrachian from the Early Permian of Texas and the origin of frogs and salamanders

Jason S. Anderson[1], Robert R. Reisz[2], Diane Scott[2], Nadia B. Fröbisch[3] & Stuart S. Sumida[4]

Gerobatrachus

Anderson et al. 2008

overlying fragment of the femur. An element identified as a sacral rib

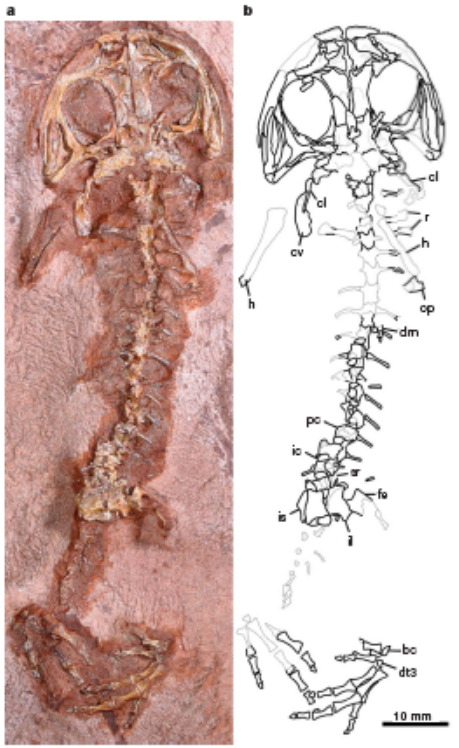

Figure 1 | *Gerobatrachus hottoni*, gen. et sp. nov., holotype specimen USNM 489135. Complete specimen in ventral view, photograph (left) and interpretive outline drawing (right). Abbreviations: bc, *basale commune*; cl, cleithrum; cv, clavicle; dm, digital elements of the manus; dt3, distal tarsal 3; fe, femur; h, humerus; ic, intercentrum; il, ilium; is, ischium; op, olecranon process of ulna; pc, pleurocentrum; r, radius; sr, sacral rib.

articulate with the proximal surfaces of metatarsals 1 and 2, it would

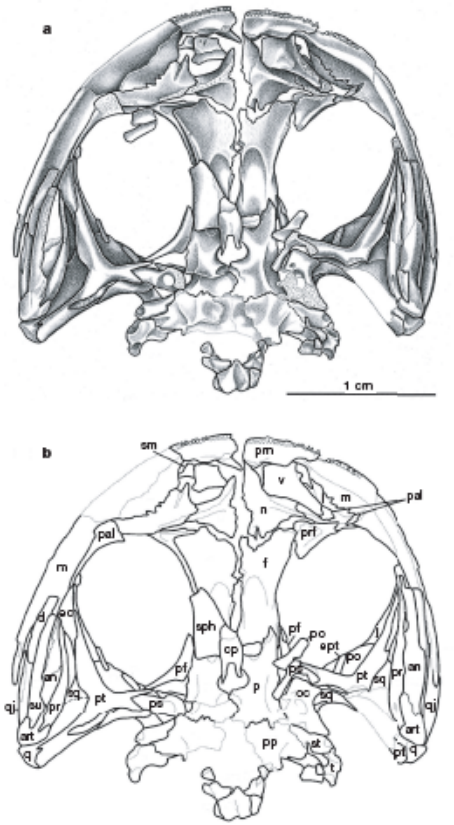

Figure 2 | *Gerobatrachus hottoni*, gen. et sp. nov., holotype specimen USNM 489135. a, Close-up interpretive specimen, and b, outline drawing of skull in ventral view. Abbreviations are the same as for Fig. 1 and: an, angular; art, articular; cp, cultriform process of parasphenoid; d, dentary; ec, ectopterygoid; ept, epipterygoid; f, frontal; j, jugal; l, lacrimal; m, maxilla; n, nasal; oc, portion of otic capsule; p, parietal; pal, palatine; pf, postfrontal; pm, premaxilla; po, postorbital; pp, postparietal; pr, prearticular; prf, prefrontal; ps, parasphenoid; pt, pterygoid; q, quadrate; qj, quadratojugal; sm, septomaxilla; sph, sphenethmoid; sq, squamosal; st, supratemporal; su, surangular; t, tabular; v, vomer.

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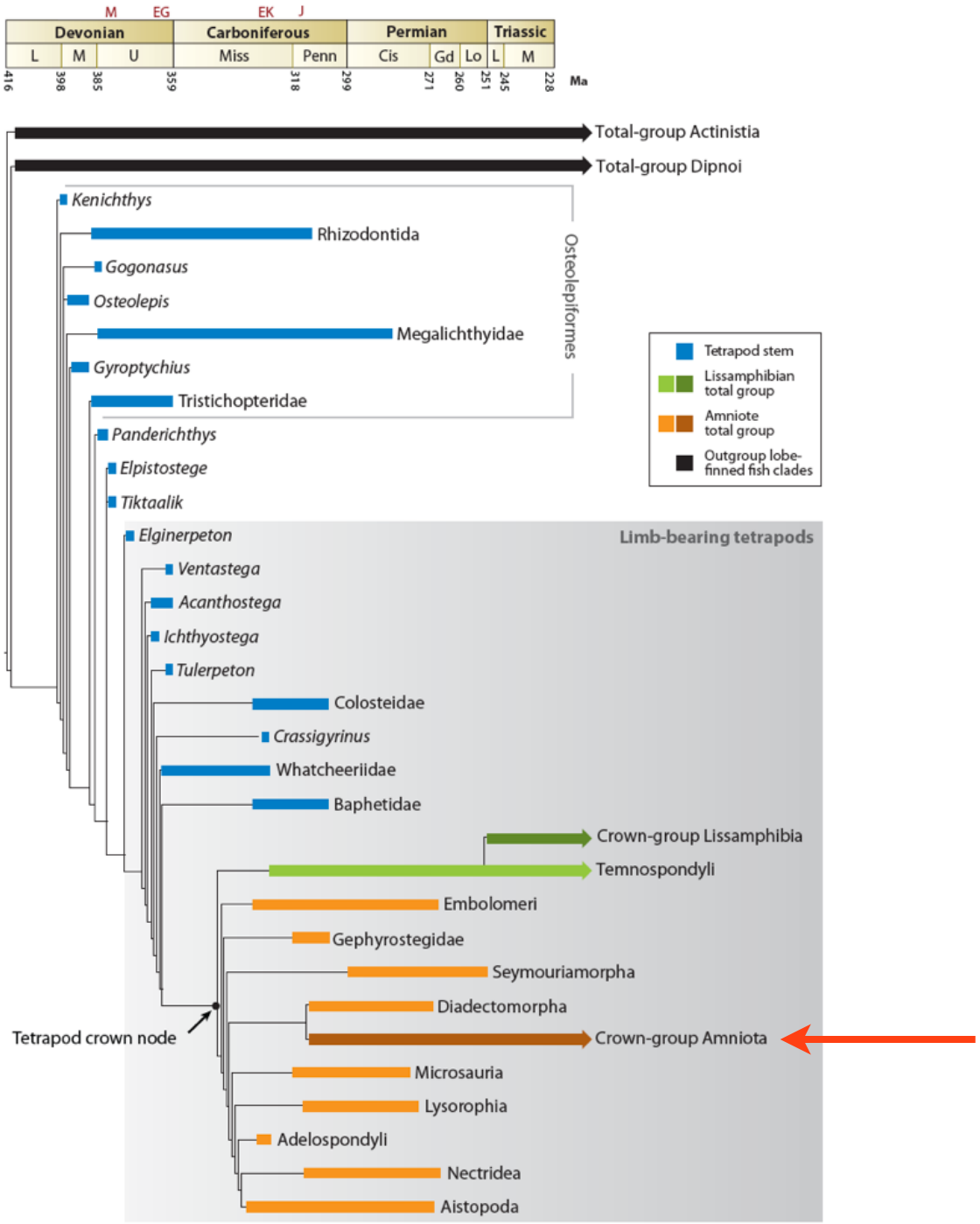
Art by Michael Skrepnick

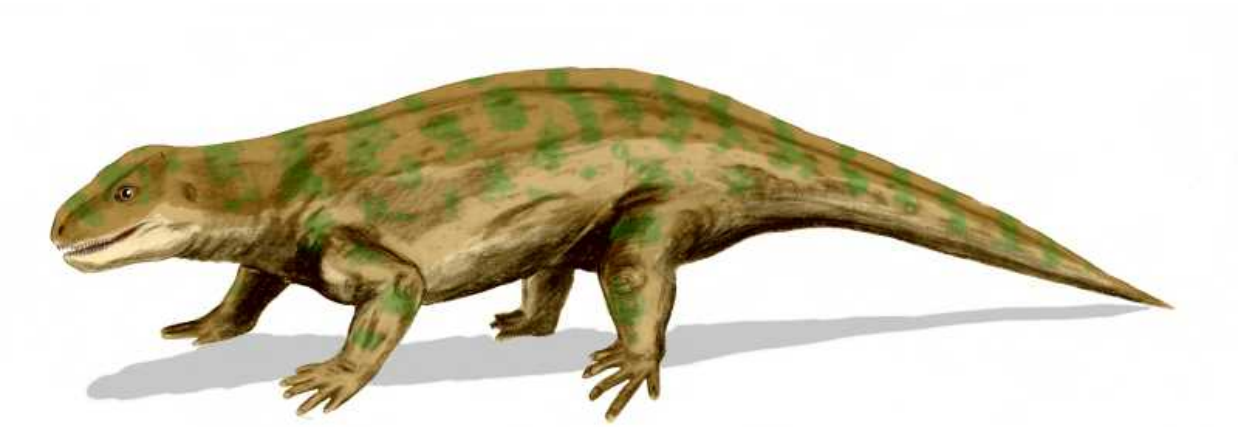
Gerobatrachus:
The “frogamander”



Coates et al. 2008

Early Evolution in Amniotes

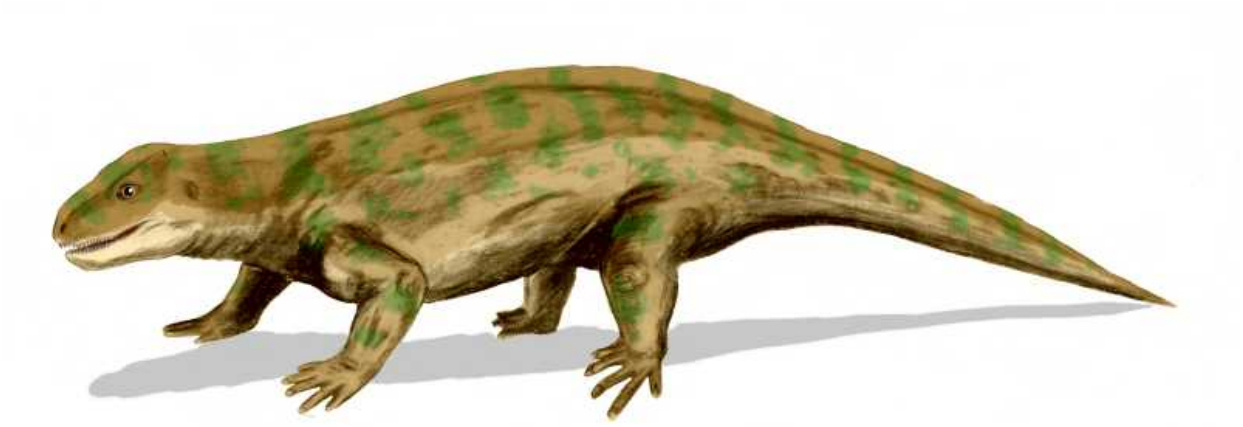
- Amniota derives from the possession of an amniotic egg
- Sister group to amniotes: *Diadectomorpha*



Diadectes, from wikipedia

Early Evolution in Amniotes

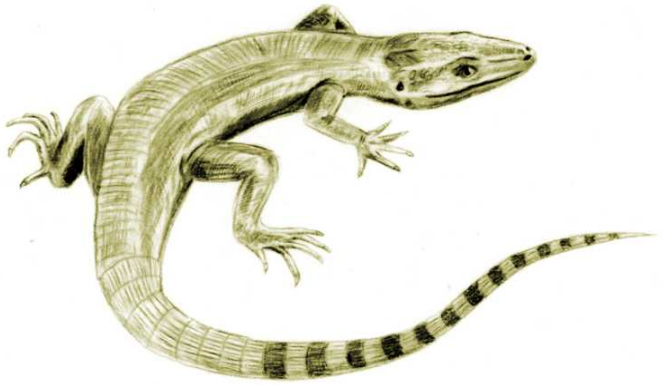
- A large number of derived traits are shared by didactomorphs and amniotes
- Soon after, there is a major split in the amniotes



Diadectes, from wikipedia

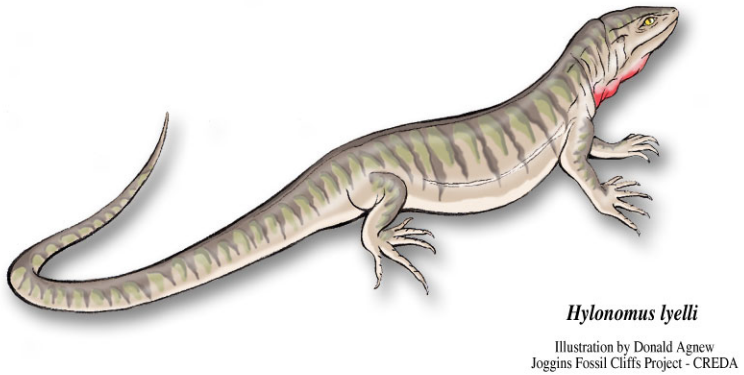
Division in the amniotes

Synapsids

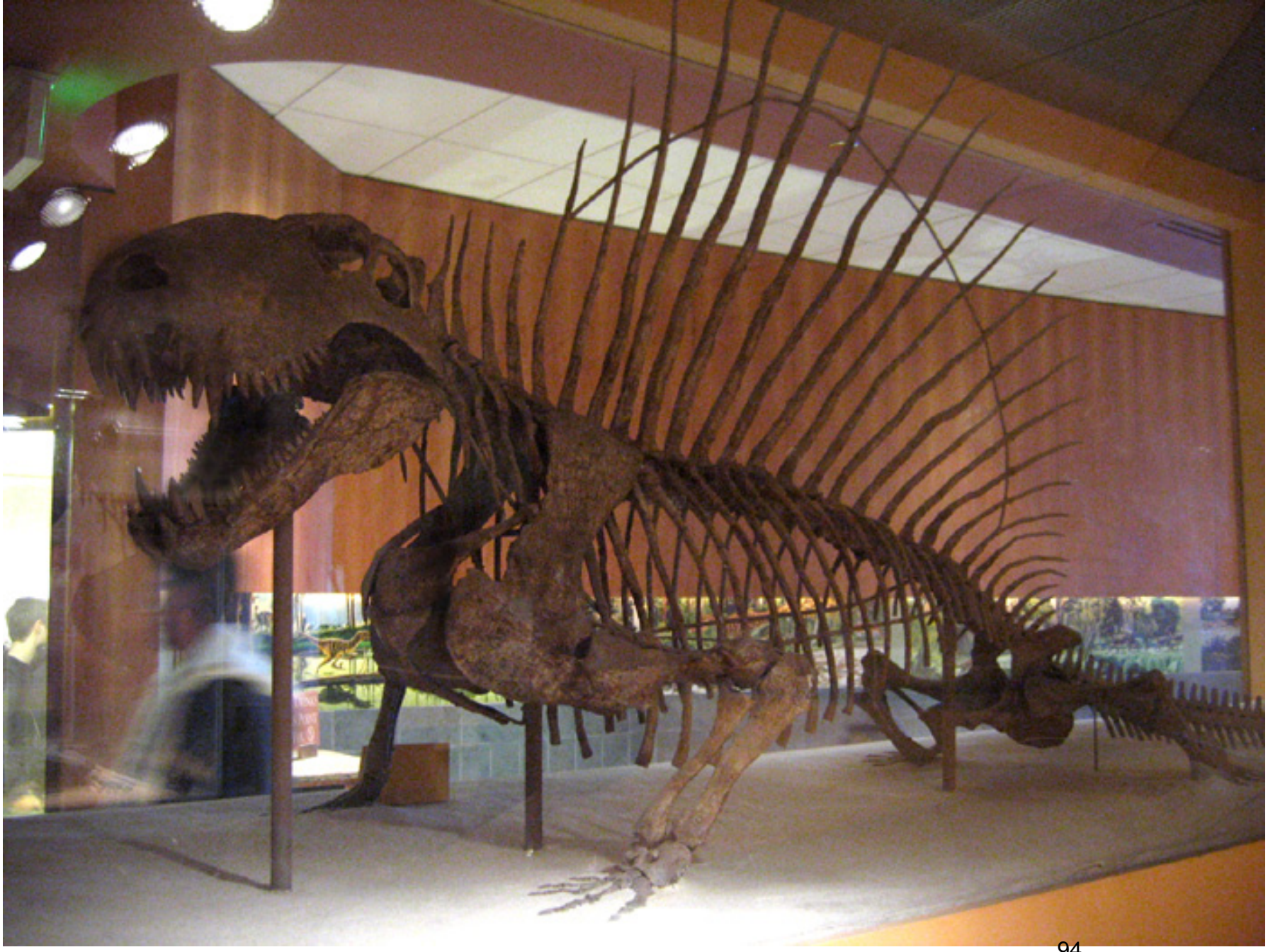


Archaeothyris,
an early synapsid

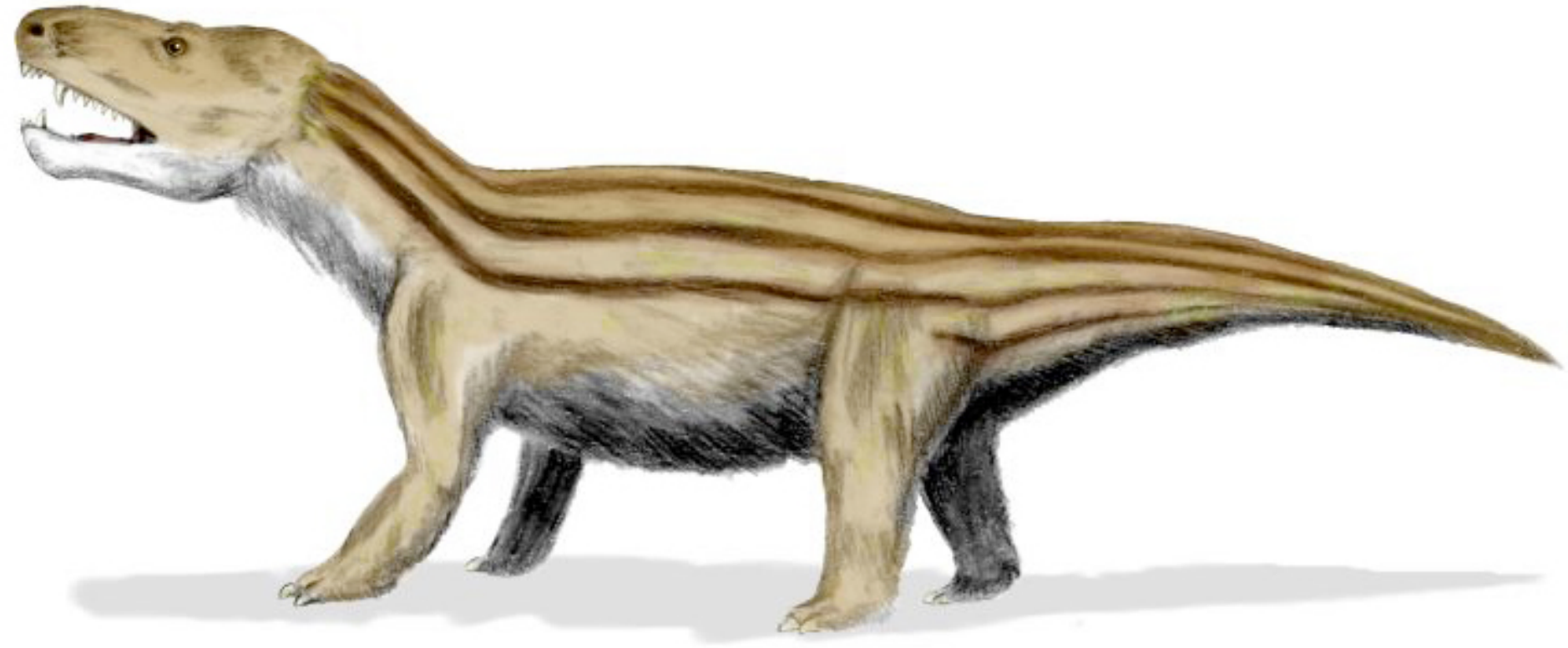
Reptiles



Hylonomus,
an early reptile

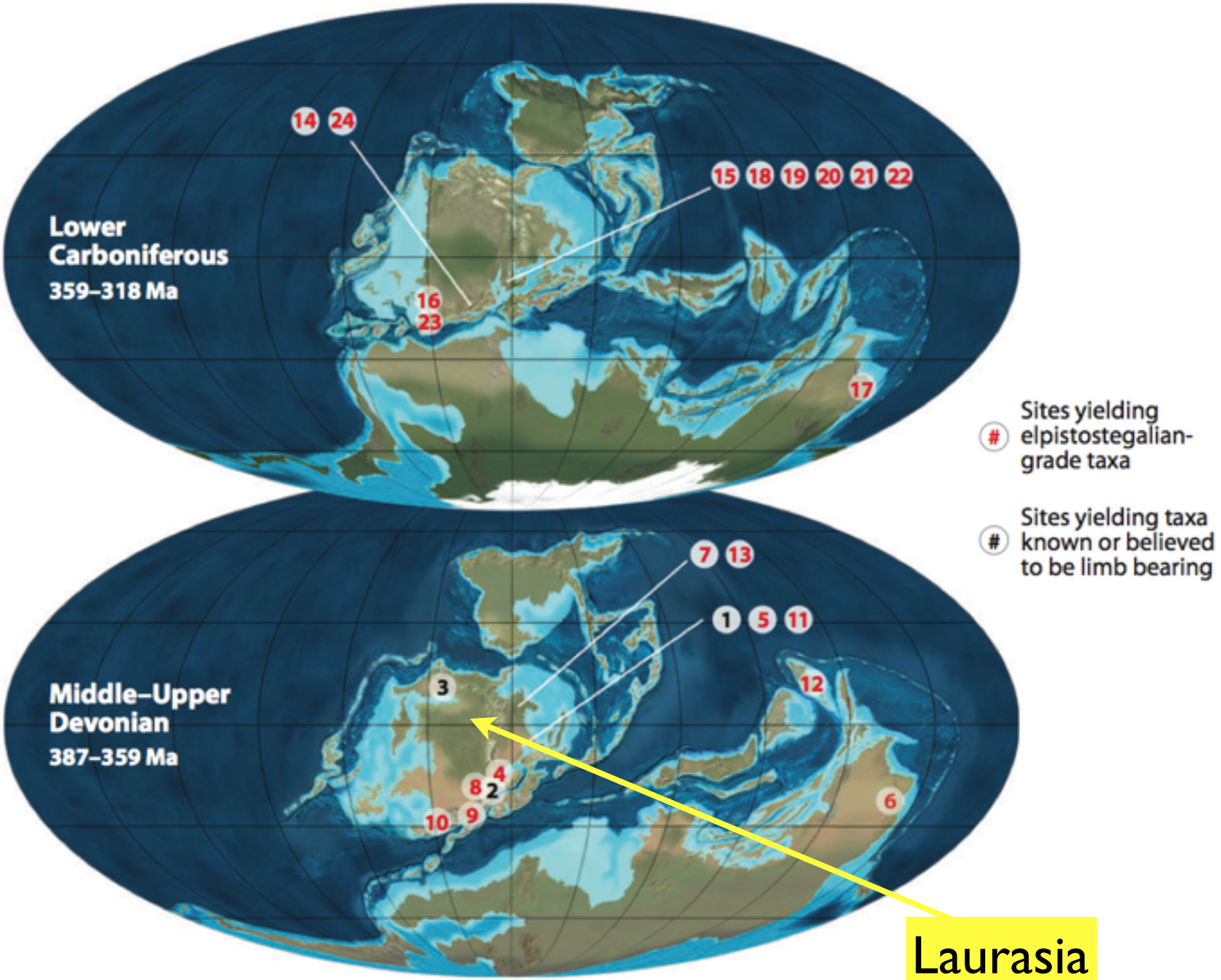


Fossil skeleton of *Dimetrodon grandis*, National Museum of Natural History, Washington, DC.



Cynognathus

Where did this all take place?


Lower
Carboniferous
359–318 Ma
14
24
15
18
19
20
21
22
16
23
17
Middle–Upper
Devonian
387–359 Ma
7
13
1
5
11
12
3
4
8
2
10
9
6
Sites yielding elpistostegalian-grade taxa
Sites yielding taxa known or believed to be limb bearing
Laurasia

Devonian

Carboniferous









Overview of tetrapod diversity